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OF THE

GEOLOGICAL SOCIETY OF LONDON.

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PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

LONDON:

LONGMAN, BROWN, GREEN, AND LONGMANS.

PARIS:—FRIED. KLINCKSIECK, 11 RUE DE LILLE; BAUDRY, 9 RUE DU COQ, PRES LE LOUVRE; LEIPZIG, T. O. WEIGEL.

SOLD ALSO AT THE APARTMENTS OF THE SOCIETY.

MDCCCLIII.

List

OF THE

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OF THE

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S. V. Wood, Esq.

Assistant-Secretary, Curator, and Librarian.

T. Rupert Jones, Esq.

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ERRATA.

PART I. Page 29, after the title insert [Read June 16, 1852.]

— — 87, lines 4 & 5 from top, *for* rachide utroque latiore, dentibus prominulis, *read* rhachide utroque dentibus prominulis (nec confertis) latiore.

— — 114, line 12 from bottom, *for* are *read* is.

— — 129, — 19 from bottom, for *tigerrina* read *tigerina.*

— — 130, — 15 from top, *for* these *read* the molluscs.

— — 165, — 8 from top, *for* Cerrig-y-lladion *read* Cerrig-y-lladron.

— — 167, — 10 from bottom, *dele* impossibility of tracing the beds.

— — —, — 9 from bottom, *after* heretofore *read* erroneously.

— — 168, bottom line, *for* high *read* last.

— — 169, line 13 from bottom, *for* Yuys-dulas *read* Ynys-dulas.

— — 172, — 9 from top, *before* were *read* interbedded rocks.

— — 197, — 9 from bottom, *for* formed *read* found.

Directions to the Binder.

The binder is directed to place opposite page 50, Part I. the loose slip relating to the Fossil Plants from Shetland.

GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 18, 1853.

REPORT OF THE COUNCIL.

The Council, in laying their Annual Report before the Society, call their attention to the satisfactory condition of their affairs. Their numbers, which in 1851 had undergone a slight diminution, have, in the past year, experienced an increase. During the past year 20 new Fellows have been elected, and those elected in 1851 have paid their admission-fees in the past year: in all, 23. The Society has lost 19 Fellows by deaths, and 1 has resigned; in all, 20: which, deducted from 23, the number of new Fellows, leaves an increase to the Society of 3. The Society has further lost an Honorary Member by death; thus reducing the total increase of the Society to 2.

The total number of the Society in 1852 was 864; and, in the present year, 866.

The expenditure during the past year has exceeded the income by £145 9*s.* 8*d.* This has arisen from the unusual outlay in illustrating Memoirs published in the Quarterly Journal; the importance of those communications, in the judgement of the Council, fully justifying the expenditure.

The Council would here call the attention of the Society to the fact, that the number of its Members who are contributors to the Journal is very limited. The Society must be sensible that an increased sale of their publications is of the highest importance, and would greatly add to their means of illustrating the valuable Memoirs which are daily sent in: they confidently trust that they shall have it in their power at the next Annual Meeting to report that they are experiencing increased support.

The excess of income over expenditure during the last five years is £70 12*s.* 3*d.*

The number of compounders at the close of 1851 was 133, and at the close of 1852 was also 133; two Fellows having died, and two Fellows having compounded during that period. One of these compositions, together with two received in 1851, too late to be

funded in that year, have been invested in the Funds. The total amount received from these 133 compounders is £4189 10*s*. The amount of Stock held by the Society at the close of 1851 was £3792 3*s*. 11*d*., and at the close of 1852, £3888 10*s*. 6*d*., while one composition remains in hand to be invested in the present year. The estimated value of the Society's Stock at the close of the past year, Consols being at par, was £3888 10*s*. 6*d*.

The Council have to announce the completion of Vol. VIII. of the Quarterly Journal, and the publication of the first Number of Vol. IX.

During the past year, Mr. A. Geddes Bain, the indefatigable explorer of the geology of S. Africa, and discoverer of the Dicynodon, forwarded to the Society, from the Cape of Good Hope, four additional cases of fossils, chiefly consisting of bones imbedded in a hard matrix of limestone; nineteen boxes containing similar remains and rock-specimens having been sent previously. The Council feeling the great interest that is attached to these fossils, but, at the same time, not having at their disposal the means requisite for extracting them from the matrix and preparing them for the study of the anatomist, applied to Professor Owen for advice. Professor Owen, after due consideration, recommended that the fossils should be transferred to the British Museum, with a view to their being extracted and made available for science. He, at the same time, recommended that it should be represented to the Trustees of the British Museum, that in his opinion the sum of £150 would be a reasonable remuneration to Mr. Bain for the expense he had incurred in collecting the fossils and forwarding them to the Cape. The Council acted upon both the suggestions of Professor Owen; and shortly after, had the gratification of receiving a letter from Sir H. Ellis, expressing the thanks of the Trustees for the offer of the Cape Fossils, and informing them that the sum of £150 had been awarded by the Trustees to Mr. Bain, as some remuneration for the heavy charges he had incurred.

At the last Annual Meeting it was announced to the Society, that Mr. Greenough and Mr. Sharpe had most obligingly undertaken to supply a great desideratum in the Society's Library, by colouring, geologically, Lewis's Map of Scotland. This laborious task, involving so much of research and of minute information, has been accomplished by Mr. Sharpe, with the assistance of the information supplied him by Mr. Greenough, and his Map has been laid before the Council; who immediately passed a resolution, "That the best thanks of the Council be given to Mr. Sharpe for this donation: and that Mr. Sharpe be requested to correct the Map from time to time, as new and more perfect information may be received." The Council anticipate that the Society will join them in this request, as well as in acknowledgements to Mr. Sharpe for this valuable present.

In conclusion, the Council have to announce, that they have awarded a Wollaston Palladium Medal to M. Edouard de Verneuil, and to M. le Vicomte d'Archiac, members of the Geological Society of France, for their numerous valuable contributions to geology, and

especially for their joint Memoir on "The Fossils of the older deposits in the Rhenish Provinces," published in the Transactions of the Society. The Council have further resolved, that the balance of the proceeds of the Wollaston Donation Fund be awarded to M. de Koninck, in consideration of his many valuable works on Palæontology, and in order to assist him in the publication of his work on Encrinites, now in progress.

Report of the Museum and Library Committee.

The Lower Museum.

In this department, Mr. Jones has placed in their proper drawers, all the new specimens which have been presented to the Society, which include many valuable additions to our Museum. Two glass-cases have been prepared to contain a selection from Captain Jones's valuable collection of Fish from the Mountain Limestone.

A Cabinet has also been added for the collection of rock-specimens selected by Mr. Pratt, which will be arranged as soon as that gentleman returns to England.

Mr. Pratt has carried on most zealously the arrangement of the collection of minerals placed in the Library, which now forms a most interesting portion of the Society's Museum.

Foreign Museum.

Mr. Jones has completed the geographical arrangement of the Rock-specimens commenced and carried out by Mr. Pratt, by placing in order the specimens from India, Egypt, and Australia.

Considerable progress has also been made by Mr. Jones in carrying on the arrangement of the Fossil-specimens on the scheme suggested and commenced by the Committee appointed two years ago: his labours have been principally directed to the collections from North and South Africa, New Zealand, and Australia. In this department, the Committee call particular attention to the large collection of Palæozoic and Secondary Fossils sent from the Cape of Good Hope by Mr. Bain.

Mr. Jones has prepared a separate collection of Nummulites both British and Foreign, which has been enriched by presents of English specimens from Mr. Jones himself, Belgian from Sir Charles Lyell, and many specimens from the Alps, the Carpathians, and the Himalayas from Sir R. I. Murchison; specimens from Spain also have been presented by Mr. Pratt, and from Asia Minor by Mr. Hamilton.

The Library.

The usual attention has been paid to the binding and cataloguing the additions to the Library, which have been very considerable.

During the past year, the Geological Maps of the Survey of Great Britain have been mounted on calico, in accordance with the decision of the Council, and the Sections of the Survey are being proceeded with in the same manner.

With the assistance of Mr. Tiffin, whose services were temporarily granted by the Council, Mr. Jones has been enabled to bring into

order, in portfolios*, a large mass of drawings and engravings illustrative of geological sections, Palæontology, &c.; and a MS. catalogue has been drawn up of the same, including the previous collection which had not been catalogued.

The MS. geological maps lately added have also been catalogued, and will be brought into their proper places as soon as room can be found for them.

Signed, DANIEL SHARPE.
JOHN MORRIS.
Somerset House, 7th February, 1853. SEARLES WOOD.

Comparative Statement of the Number of the Society at the close of the years 1851 *and* 1852.

	Dec. 31, 1851.		Dec. 31, 1852.	
Compounders		133		133
Residents		207		213
Non-residents		453		450
		793		796
Honorary Members	17		16	
Foreign Members	50		50	
Personages of Royal Blood	4	—71	4	—70
		864		866

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1851 *and* 1852.

Number of Compounders, Residents, and Non-residents, December 31, 1851				793
Add, Fellows elected during former years, and paid in 1852	Resident	2		
	Non-resident	1		
			— 3	
Fellows elected, and paid, during 1852	Resident	13		
	Non-resident	7		
			—20	
			—	23
				816
Deduct, Compounders deceased			2	
Residents			6	
Non-residents			11	
Resigned			1	
			—	20
Total number of Fellows, 31st Dec. 1852, as above				796

* Twelve in number, viz.—1. Geological Sections, British; 2. Ditto, Foreign; 3. Mining Plans and Veins; 4. Mineralogy; 5. Vertebrata; 6. Invertebrata; 7. Botany; 8. Theoretical Diagrams; 9. Views; 10. Surveyor's Plans; 11. Portraits; 12. Lithography.

Number of Honorary Members, Foreign Members, and Personages of Royal Blood, December 31, 1851	71
Deduct, Honorary Member deceased	1
As above	70

Number of Fellows liable to Annual Contribution at the close of 1852, with the Alterations during the year.

Number at the close of 1851		207
Add, Elected in former years and paid in 1852		2
Elected and paid in 1852....................		13
Non-residents who became Residents		3
		225
Deduct, Deceased	6	
Resigned	1	
Compounded	2	
Became Non-resident	3	
	—	12
As above		213

Deceased Fellows.

Compounders (2).

Richard Hollier, Esq. | G. A. Mantell, LL.D.

Residents (6).

William Blake, Esq.
J. D. George, Esq.
Sir J. J. Guest, Bart.
G. M. Henderson, Esq.
J. L. Prevost, Esq.
Rear-Adml. Sir T. Trowbridge.

Non-residents (11).

William Copland, Esq.
Rev. James Edmonston.
Francis Forster, Esq.
Edward Frere, Esq.
James Inglis, M.D.
Patrick Neill, M.D.
Robert Stevenson, Esq.
Prof. Thos. Thomson, M.D.
Rev. R. N. Pemberton.
David Walker, Esq.
J. B. Wigham, Esq.

Honorary Member (1).

John Williams, Esq.

The following Persons were elected Fellows during the year 1852.

January 7th.—Thomas Rupert Jones, Esq., 50 Wellclose Square; Joseph G. W. Watson, Ph.D., Old Kent Road; Rev. Charles Pritchard, A.M., Clapham; John Phear, Esq., M.A., Clare Hall, Cambridge; and James Hepburn, Esq., M.A., Tovil Place, Maidstone.

February 4th.—Rev. John Gunn, Irstead, Norwich.

April 7th.—Lieut. Julius Roberts, Portsmouth; and the Hon. Dudley Francis Fortescue, Grosvenor Square.

—— 21st.—Charles Twamley, Esq., Queen's Road, Gloucester Gate, Regent's Park; Adam Murray, Esq., Craven Street, Strand; and M. W. T. Scott, Esq., Great George Street, Westminster.

May 5th.—Capt. Robert M. Westmacott, South Audley Street.

June 2.—David Findlay, M.D., R.N., United Service Institution; William Henry Gomonde, Esq., Promenade, Cheltenham; and John Harcourt Blofeld, Esq., Royal Avenue Terrace, Chelsea.

—— 16th.—Mackay John Scobie, Esq., Hereford.

November 3rd.—Thomas Davidson, Esq., Grosvenor Place, Brixton.

December 1st.—John Moxon Clabon, Esq., Primrose Hill; James P. Fraser, Esq., New Bridge Street, Glasgow; Rev. Osmond Fisher, Dorchester; Sir Charles Fellows, Montague Place; Prof. F. M'Coy, Queen's College, Belfast; and Edward Wood, Esq., Richmond, Yorkshire.

December 15th.—F. W. S. Packman, M.D., Clarges Street; and James Arthur Morgan, Esq., Devonport Street, Hyde Park.

The following donations to the Museum have been received since the last Anniversary.

British Specimens.

Series of Specimens of Lias rocks from Gloucestershire; presented by R. W. Binfield, Esq.

2 Specimens of Phillipsia from Derbyshire; presented by Thomas Bland, Esq., F.G.S.

Fossil Bones and Shells from Portland; presented by Mr. A. Neale.

Series of Specimens from the Lias and Drift of Gloucestershire; presented by G. E. Gavey, Esq., F.G.S.

Specimen of *Nautilus pseudoelegans*, from the Grey Chalk of Lewes; presented by D. Sharpe, Esq., F.G.S.

Suite of Specimens from the Ludlow Bone Bed at Hagley Park, Herefordshire; presented by H. E. Strickland, Esq., F.G.S.

Specimens of Fossil Plants from the Shetland Islands; presented by the Right Hon. Henry Tufnell.

Foreign Specimens.

Specimens of Calamites and Sternbergia, of Conularia, and a Specimen of Fossil Fish, from the Carboniferous rocks of Nova Scotia; presented by J. W. Dawson, Esq.

23 Cases of Fossils from South Africa; presented by A. G. Bain, Esq.
Tertiary Fossils from Porto d'Anzio; presented by Sir W. C. Trevelyan, F.G.S.
Series of Fossils from Catalonia; presented by S. P. Pratt, Esq., F.G.S.
Suite of Rock Specimens from Jamaica; presented by the Royal Geographical Society.
Series of Fossils from Jamaica and Barbadoes, and 2 Specimens of Tungstate of Lime from New Grenada; presented by Thomas Bland, Esq., F.G.S.
Specimen of Manganese Ore, from the Cape of Good Hope; presented by the Rev. Dr. Adamson.
Series of Specimens from the Coral Formation of the Bahamas; presented by Capt. Nelson, R.E.
Suite of Fossil Plants from Portugal; presented by D. Sharpe, Esq., F.G.S.
Cast of Footsteps of *Sauropus primævus*; presented by J. Lea, Esq.
Specimens of Rocks, Coal, and Recent Shells from Disco Island; presented by the Lords Commissioners of the Admiralty.
Specimen of Pseudomorphous Crystals of Salt, Keuper Sandstone; presented by H. E. Strickland, Esq., F.G.S.
Suite of Nummulites from Belgium; presented by Sir C. Lyell, F.G.S.
Suite of Rock Specimens from China; presented by Sir G. T. Staunton, Bart., F.G.S.
Nummulites from Asia Minor; presented by W. J. Hamilton, Esq., Sec. G.S.
Suite of Nummulites from India, the Alps, and the Carpathians; presented by Sir R. I. Murchison, F.G.S.

Charts and Maps.

The Charts, &c., published by the Admiralty during the year 1851; presented by Rear-Admiral Sir F. Beaufort, Hon. M.G.S., by direction of the Lords Commissioners of the Admiralty.
Map No. 61, S.E., and Sections Nos. 20, 21, 26 and 27 of the Geological Survey of Great Britain; presented by Sir H. T. De la Beche, F.G.S. (on the part of Her Majesty's Government).
5 Charts published by the Dépôt de la Marine in 1850, 23 published in 1851, and 1 published in 1852; presented by M. le Directeur Général du Dépôt de la Marine.
MS. Geological Map of South Africa, with Sections, by A. G. Bain; presented by the Author.
Chart of the American Arctic Expedition in search of Sir J. Franklin, 1851; presented by the Superintendent of the United States National Observatory.
Profile of the Country from the St. Croix to the St. John, by Major J. D. Graham; presented by the Smithsonian Institution.
A Geological Map of Somersetshire, by J. D. Pring, Esq.; presented by the Author.

Geological Map and Sections of the District between Frankfort, Giessen, Fulda, and Hammelburg, by R. Ludwig, 1852; presented by the Middle Rhine Geological Society.

Map of the Route between Pekin and Canton, China; presented by Sir G. T. Staunton, Bart., F.G.S.

Map of Scotland, geologically coloured by D. Sharpe, Esq., F.G.S.; presented by the Author.

Arrowsmith's Map of S.-Eastern Australia, with its Gold Fields; presented by T. R. Jones, Esq., F.G.S.

Section of the Well sunk at the Bank of England, 1851; presented by R. W. Mylne, Esq., F.G.S.

The following List contains the Names of the Persons and Public Bodies from whom Donations to the Library and Museum were received during the past year.

Académie des Sciences de Montpellier.
Académie Royale des Sciences de Belgique.
Academy of Natural Sciences of Philadelphia.
Academy of Sciences of Breslau.
Academy of Sciences of Paris.
Adamson, Rev. Dr.
Admiralty, The Right Hon. the Lords Commissioners of the.
Akademie der Wissenschaften zu Berlin.
American Academy of Arts and Sciences.
American Philosophical Society.
Ansted, Prof. D. T., F.G.S.
Architect and Building Gazette, Editor of.
Asiatic Society of Bengal.
Athenæum Club.
Athenæum Journal, Editor of.

Bain, A. G., Esq.
Berwickshire Naturalists' Club.
Beyrich, Herr E.
Binfield, W. R., Esq.
Binney, E. W., Esq.
Bland, T., Esq., F.G.S.
Blum, Dr. Reinhard.
Bologna Academy.
Bombay Branch Royal Asiatic Society.
Bosquet, M. J.
British Association for the Advancement of Science.
Brooke, H. J., Esq., F.G.S.
Buch, Herr L. von, For. M.G.S.
Buvignier, M. A.

Cambridge Philosophical Society.
Campbell, D. F., Esq.
Canadian Journal, Editor of the.
Carter, H. J., Esq.
Charlesworth, E., Esq., F.G.S.
Chemical Society of London.
Civil Service Gazette, Editor of the.
Clarke, Rev. W. B., F.G.S.
Colonial Office.

Dana, J. D., Esq., For. M.G.S.
Davidson, Thomas, Esq., F.G.S.
Davies, Rev. J. H.
Davis, Mr. John.
Dawson, J. W., Esq.
De la Beche, Sir H. T., F.G.S.
Delesse, M. Achille.
Dépôt Général de la Marine de France.
Deslongchamps, M. E.
D'Hombres-Firmas, L.-A. Baron.
D'Orbigny, M. Alcide, For. M.G.S.

Dumont, M. A. H., For. M.G.S.

East India Company, The Hon.
École des Mines de Paris.
Egerton, Sir Philip G., M.P., F.G.S.
Ehrlich, Herr Carl.
Élie de Beaumont, M. L., For. M.G.S.
Enniskillen, Earl of, F.G.S.
Exhibition of all Nations, Commissioners of the.

Faraday, M., Esq., D.C.L., F.G.S.
Forchammer, Prof., For. M.G.S.
Freeman, Rev. John.

Garza, Prof. F. N. y.
Gasc, M. F.
Gavey, G. E., Esq., F.G.S.
Gautier, M. A.
Geological Institute of Vienna.
Geological Society of Berlin.
Geological Society of Dublin.
Geological Society of France.
Gervais, M. Paul.
Glaisher, J., Esq.
Glasgow Philosophical Society.
Gorini, Signor P.
Gould, N., Esq.
Greenough, G. B., Esq., V.P.G.S.
Gumbel, M. T.
Gunn, Rev. J., F.G.S.

Haidinger, Herr W., For. M.G.S.
Hamburg Society of Natural Sciences.
Hamilton, W. J., Esq., Sec. G.S.
Haughton, Rev. S.
Hausmann, Prof. J. F. L., For. M.G.S.
Helmerson, Col. G. von, For. M.G.S.
Henwood, W. J., Esq., F.G.S.
Hope, Lieut.-Col., R.E.
Hübertz, Dr. J. R.
Hunt, Carew, Esq.

Jenkyn, Rev. T. W., D.D., F.G.S.
Imperial Academy of Sciences of Vienna.
Indian Archipelago Journal, Editor of.
Institute of Actuaries.
Jones, T. R., Esq., F.G.S.
Journal of Microscopical Science, the Publishers of the.
Italian Society of Science of Modena.

King, Capt. P., R.N.
Koninck, Dr. L. de.

Lea, J., Esq.
Leicester Literary and Philosophical Society.
Linnean Society.
Literary and Philosophical Society of Manchester.
London Library, Committee of.
London (Watford) Spring Water Company.
Lyceum of Natural History, New York.
Lyell, Sir Charles, F.G.S.

M. C.
M'Coy, Prof., F.G.S.
Meyer, Herr Herman von, For. M.G.S.
Middle Rhine, Geological Society of the.
Milano, Imp. R. Instituto Lombardo de Scienze in.
Miller, W. H., Esq.
Moore, J. C., Esq., Sec. G.S.
Murchison, Sir R. I., F.G.S.
Muséum d'Histoire Naturelle de Paris.
Museum of Practical Geology.
Mylne, R. W., Esq., F.G.S.

Neale, Mr. A.
Nelson, Capt., R.E.
North British Review, Publishers of the.

Palæontographical Society.
Perrey, Prof. A.
Pictet, Prof. F. J.
Pole, Wm., Esq., F.G.S.

Pratt, S. P., Esq., F.G.S.
Pring, S. D., Esq.
Purslo, Joshua, Esq.

Quetelet, M. A.

Ray Society.
Roemer, Dr. F.
Royal Academy of Munich.
Royal Academy of Sciences of Madrid.
Royal Academy of Stockholm.
Royal Academy of Turin.
Royal Agricultural Society of England.
Royal Asiatic Society.
Royal College of Surgeons.
Royal Cornwall Polytechnic Society.
Royal Geographical Society.
Royal Geological Society of Cornwall.
Royal Institution.
Royal Society.
Royal Society of Copenhagen.
Royal Society of Edinburgh.
Royal Society of Van Diemen's Land.
Rouse, W., M.D.

Sabine, Colonel, F.G.S.
Scarborough Philosophical Society.
Sedgwick, Rev. Prof., F.G.S.
Sharpe, D., Esq., F.G.S.
Silliman, Prof., M.D., For. M.G.S.
Sismonda, Prof. Angelo, For. M.G.S.
Sismonda, Prof. Eugenio.
Smithsonian Institution.
Société d'Agriculture, Science, Arts et Commerce du Puy.
Société de Physique et d'Histoire Naturelle de Genève.
Société Impériale des Naturalistes de Moscou.
Société Linnéenne de Bordeaux.
Society of Arts.
Sorby, H. C., Esq., F.G.S.
Strickland, H. E., Esq., F.G.S.
Sykes, Col., F.G.S.

Taylor, R., Esq., F.G.S.
Trevelyan, Sir W. C., F.G.S.
Trimmer, Joshua, Esq., F.G.S.
Tufnell, Rt. Hon. Henry.

United States National Observatory.

Vaudoise Société des Sciences Naturelles.

Warren, J. C., M.D.
Wheelwright, H. W., Esq.
Willkomm, Dr. Moritz.
Wisbaden Natural History Society.

Zoological Society.

List of Papers *read since the last Anniversary Meeting, February 20th,* 1852.

1852.

Feb. 25th.—On the Classification of the Lower Palæozoic Rocks of Great Britain, by the Rev. Professor Sedgwick, F.G.S.

March 10th.—On the Upper Tertiaries at Copford, Essex, by John Brown, Esq., F.G.S.

———— On a Reversed Fault at Lewisham, by the Rev. H. M. de la Condamine, F.G.S.

———— Notes on the Island of St. Helena, by J. H. Blofeld, Esq., F.G.S.

1852.

March 10th.—Description of some Fossil Land Shells from St. Helena, by Prof. E. Forbes, F.G.S.

March 24th.—On the Foot Tracks in the Potsdam Sandstone of Lower Canada, by W. E. Logan, Esq., F.G.S.

———— Description of the Potsdam Sandstone Foot Tracks (*Protichnites*), by Prof. R. Owen, F.G.S.

April 7th.—On some of the Effects of the Holmfirth Flood, by Joseph Prestwich, Jun., Esq., F.G.S.

———— On the Salt range of the Punjaub, by Dr. A. Fleming; communicated by Sir R. I. Murchison, F.G.S.

———— Geological Notice of the Country around Kotah, Deccan, by Dr. T. L. Bell; communicated by Colonel Sykes, F.G.S.

April 21st.—Letter on the Occurrence of an Earthquake Shock at Bristol, by Major Thomas Austin, F.G.S.

———— On the Lower Eocene Strata (Thanet Sands) of England, by Joseph Prestwich, Jun., Esq., F.G.S.

May 5th.—On the Tertiary Formations of Belgium and their British Equivalents, by Sir Charles Lyell, F.G.S. Part I. On the Pliocene, Miocene, and Upper Eocene of Belgium.

———— On the Geology of Catalonia, by Samuel Peace Pratt, Esq., F.G.S.

May 19th.—On the Soils covering the Chalk of Kent, by Joshua Trimmer, Esq., F.G.S. Part 2.

———— On the Tertiary Formations of Belgium and their British Equivalents, by Sir Charles Lyell, F.G.S. Part 2. On the Lower Tertiaries.

June 2nd.—On the Geology of the Bahamas, and on Coral Formations generally, by Capt. Nelson; communicated by Sir Charles Lyell, F.G.S.

———— On some Fossil Plants from the Lower Trias of Warwickshire, by George Lloyd, M.D., F.G.S.

June 16th.—On the Silurian Rocks of the S. of Scotland, and on the Gold Districts of Wanlockhead and the Lead Hills, by Robert Harkness, Esq.; communicated by J. C. Moore, Esq., Sec. G.S.

———— Description of some Graptolites from the South of Scotland, by J. W. Salter, Esq., F.G.S.

———— On a protruded Mass of Ludlow Rock at Hagley Park, Herefordshire, by H. E. Strickland, Esq., F.G.S.

———— Description of the *Pterygotus problematicus*, by J. W. Salter, Esq., F.G.S.

———— On the Comparison of the Devonian Series of Belgium and England, by Daniel Sharpe, Esq., F.G.S.

———— On the Comparison of the Tertiary Series of Belgium and England, by M. A. M. Dumont, For. M.G.S.

———— On the meaning of the term "Silurian System," by Sir R. I. Murchison, F.G.S.

———— Further Remarks on the Ornithoidichnites of the Weald, by S. H. Beckles, Esq.; communicated by Sir Charles Lyell, F.G.S.

June 16th.—Further Remarks on the Red Sandstone of Nova Scotia, by J. W. Dawson, Esq.; communicated by Sir Charles Lyell, F.G.S.

———— Comparison of Bubble Marks and Rain Prints, by M. E. Désor; communicated by the President.

———— On the Sections of the Lower Lias at Mickleton and Aston, by G. E. Gavey, Esq., F.G.S.

———— On the Foot Tracks in New Red Sandstone, by Robert Rawlinson, Esq.; communicated by the Earl of Ellesmere, F.G.S.

———— On the Geology of the Lake of the Woods, by J. J. Bigsby, M.D., F.G.S.

———— On the Geology of the Southern Portion of Cantyre, by Prof. J. Nicol, F.G.S.

November 3rd.—On a Proposed Separation of the Caradoc Sandstone into two distinct Groups, viz. the May Hill Sandstone and the Caradoc Sandstone, by the Rev. Prof. Sedgwick, F.G.S.

November 17th.—Notice of the Occurrence of an Earthquake at the Azores, by C. T. Hunt, Esq.; communicated from the Foreign Office by order of Lord Malmesbury.

———— On the Geology of Southern Africa, by A. G. Bain, Esq.; communicated by the President.

December 1st.—On the Distribution and Organic Contents of the Ludlow Bone Bed, in the Districts of Woolhope and May Hill, by H. E. Strickland, Esq., F.G.S.

———— On the Fish Remains in the Ludlow Bone Bed, by Sir R. I. Murchison, F.G.S.

———— Note on the supposed Fish Remains figured in Plate 4 of the "Silurian System," by Prof. F. M'Coy, F.G.S.

———— On Pseudomorphous Crystals of Chloride of Sodium, in the Keuper Sandstone, by H. E. Strickland, Esq., F.G.S.

December 15th.—On Changes in the Sea Level effected by existing Physical Causes during stated periods of time, by Alfred Tylor, Esq., F.G.S.

1853.

January 5th.—On the Geology of the Island of Labuan and the Neighbourhood, by — Motley, Esq.; communicated by Sir H. T. De la Beche, F.G.S.

———— On the Occurrence of Insect Remains in the Tertiary Clays of Dorsetshire, by the Rev. P. B. Brodie, F.G.S.

———— On the Occurrence of an Elytron of a Coleopterous Insect in the Kimmeridge Clay of Ringstead Bay, Dorsetshire, by the Rev. P. B. Brodie, F.G.S.

———— Notice of Fossil Plants from the Shetland Islands; in a letter from the Rt. Hon. H. Tufnell to Sir R. I. Murchison, F.G.S.

January 19th.—On the Remains of Reptiles and a Land Shell discovered in the Interior of an Erect Fossil Tree in the Coal Measures of Nova Scotia, by Sir Charles Lyell, F.G.S., and J. W. Dawson, Esq.

———— On the Remains of the Batrachian Reptiles found in

1853.
Nova Scotia by Sir Charles Lyell and Mr. Dawson, by Prof. J. Wyman: with Notes on the same, by Prof. R. Owen, F.G.S.
January 19th.—Notice of a Batrachoid Fossil from British Coal-shale in the Museum of the Earl of Enniskillen, by Prof. R. Owen, F.G.S.
February 2nd.—On the Geology of the Himalayas in the Vicinity of Subatoo, by Major Vicary; communicated by Sir R. I. Murchison, F.G.S.
———— On the Gold Fields of Victoria, by G. H. Wathen, Esq.; communicated by P. N. Johnson, Esq., F.G.S.

After the Reports had been read, it was resolved,—

That they be received and entered on the Minutes of the Meeting; and that such parts of them as the Council shall think fit be printed and distributed among the Fellows.

It was afterwards resolved,—

1. That the thanks of the Society be given to William Hopkins, Esq., retiring from the office of President.

2. That the thanks of the Society be given to R. A. C. Austen, Esq., G. B. Greenough, Esq., and S. V. Wood, Esq., retiring from the office of Vice-President.

3. That the thanks of the Society be given to J. C. Moore, Esq., retiring from the office of Secretary.

4. That the thanks of the Society be given to Prof. Ansted, Prof. Graham, Prof. Ramsay and W. W. Smyth, Esq., retiring from the Council.

After the Balloting Glasses had been duly closed, and the lists examined by the Scrutineers, the following gentlemen were declared to have been duly elected the Officers and Council for the ensuing year:—

OFFICERS.

PRESIDENT.

Prof. E. Forbes, F.R.S. and L.S.

VICE-PRESIDENTS.

Sir Charles Lyell, F.R.S. and L.S.
John Carrick Moore, Esq., M.A.
Prof. R. Owen, M.D., LL.D., F.R.S. and L.S.
Lieut.-Col. Portlock, R.E., F.R.S.

SECRETARIES.

R. A. C. Austen, Esq., B.A., F.R.S.
William John Hamilton, Esq.

FOREIGN SECRETARY.

C. J. F. Bunbury, Esq., F.L.S.

TREASURER.

D. Sharpe, Esq., F.R.S. and L.S.

COUNCIL.

R. A. C. Austen, Esq., B.A., F.R.S.
John J. Bigsby, M.D.
James S. Bowerbank, Esq., F.R.S. and L.S.
C. J. F. Bunbury, Esq., F.L.S.
Prof. E. Forbes, F.R.S. and L.S.
G. B. Greenough, Esq., F.R.S. and L.S.
William John Hamilton, Esq.
J. D. Hooker, M.D., F.R.S. and L.S.
William Hopkins, Esq., M.A., F.R.S.
Leonard Horner, Esq., F.R.S. L. and E.
P. N. Johnson, Esq., F.R.S.
Sir Charles Lyell, F.R.S. and L.S.
John C. Moore, Esq., M.A.
John Morris, Esq.
Sir R. I. Murchison, G.C.St.S., F.R.S. and L.S.
Prof. R. Owen, M.D., LL.D., F.R.S. and L.S.
John Percy, M.D., F.R.S.
John Phillips, Esq., F.R.S.
Lieut.-Col. Portlock, R.E., F.R.S.
Samuel Peace Pratt, Esq., F.R.S. and L.S.
D. Sharpe, Esq., F.R.S. and L.S.
Capt. Richard Strachey.
S. V. Wood, Esq.

Trust Accounts.

Receipts.	£	s.	d.	£	s.	d.
Balance at Banker's, 1st of January 1852, on the Wollaston Donation Fund	32	7	6			
Balance at Banker's, Geological Map Fund	11	10	0			
Total at Banker's, Jan. 1st, 1852				43	17	6
Received on account of the Geological Map (sold)	19	0	0			
Dividends on the Donation Fund of 1084*l.* 1*s.* 1*d.* Red. 3 per Cents.	31	11	6			
				50	11	6
				£94	9	0

Payments.	£	s.	d.
Award to Mr. J. Morris	32	0	6
Cost of Engraving Wollaston Medal, awarded to Dr. Fitton	0	7	0
Paid on account of Geological Map: Mr. Greenough, Balance of 1851	11	10	0
Balance at Banker's, Trust Account	50	11	6
	£94	9	0

We have compared the books and vouchers presented to us with these statements and find them correct.

DANIEL SHARPE,
ALFRED TYLOR, } *Auditors.*

Jan. 31, 1853.

Valuation *of the Society's Property; 31st December*, 1852.

Property.	£	s.	d.	£	s.	d.
Due from Messrs. Longman and Co., on Journal, Vol. VIII.				54	17	1
Due for Subscriptions to Journal				31	10	0
Balance in Banker's hands				300	2	7
Balance in Clerk's hands				21	9	5
Funded Property, 3888*l.* 10*s.* 6*d.* Consols				3888	10	6
Arrears of Admission Fees (considered good)	39	18	0			
Arrears of Ann. Contributions prior to 1852 (considered good)	15	15	0			
Arrears of Contributions of 1852	34	13	0			
				90	6	0
				£4386	15	7

Debts.	£	s.	d.
Balance in favour of the Society	4386	15	7
	£4386	15	7

[*N.B. The value of the Mineral Collections, Library, Furniture, stock of unsold Transactions, Proceedings, Quarterly Journal, and Library Catalogue is not here included.*]

Jan. 31, 1853. L. HORNER, *Treas. pro tem.*

INCOME.

	£	s.	d.	£	s.	d.
Outstanding, 1851:						
Quarterly Journal, Vol. VII. (Messrs. Longman & Co.) paid June 12th				66	11	1
Balance at Banker's, January 1, 1852	475	17	4			
Balance in Clerk's hands	1	4	10			
				477	2	2
Compositions at Banker's, Jan. 1, 1852				63	0	0
Compositions received	31	10	0			
Compositions received in December after Consols shut	31	10	0			
				63	0	0
Arrears of Admission Fees	23	2	0			
Arrears of Annual Contributions	37	16	0			
				60	18	0
Admission Fees of 1852				155	8	0
Annual Contributions of 1852				636	16	6
Dividends on 3 per cent. Consols				111	16	11
Sale of Transactions				2	17	0
Sale of Proceedings				2	5	6
Journal, Vol. I., allowance on sale from the Publisher				0	5	0
Sale of Journal, Vol. II.				4	0	6
Sale of Journal, Vol. III.				5	3	6
Sale of Journal, Vol. IV.				5	16	6
Sale of Journal, Vol. V.				6	15	6
Sale of Journal, Vol. VI.				10	17	6
Sale of Journal, Vol. VII.				44	4	6
Sale of Journal, Vol. VIII.*				167	10	5
Sale of Library Catalogue				1	0	0
				£1885	8	7

We have compared the Books and Vouchers presented to us with these Statements, and find them correct.

Jan. 31, 1853.

DANIEL SHARPE,
ALFRED TYLOR, } *Auditors.*

* Due from Messrs. Longman and Co., on Journal, Vol. VIII. £54 17 1

Year ending December 31st, 1852.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Outstanding, 1851:						
Quarterly Journal, Vol. VII. (Mr. R. Taylor)				37	16	0
House Repairs (Mr. G. Laing)				15	8	6
Compositions invested				94	10	0
General Expenditure:						
Taxes	22	9	6			
Fire Insurance	3	0	0			
House Repairs	9	2	3			
Furniture Repairs	10	5	11			
New Furniture	26	14	8			
Fuel	34	4	0			
Light	29	10	0			
Miscellaneous House Expenses, including Postages	46	7	9			
Stationery	14	19	1			
Miscellaneous Printing	29	4	6			
Tea for Meetings	21	13	6			
				247	11	2
Salaries and Wages:						
Assistant Secretary and Curator	200	0	0			
Clerk	120	0	0			
Porter	80	0	0			
House Maid	33	4	0			
Occasional Attendants	10	0	0			
Collector	20	9	11			
				463	13	11
Library				44	12	4
Museum				5	11	6
Diagrams at Meetings				13	4	0
Miscellaneous Scientific Expenses				16	10	8
Contributions of 1852 repaid				9	9	0
Publications:						
Transactions	0	4	4			
Journal, Vol. I.	0	3	0			
Journal, Vol. III.	1	10	0			
Journal, Vol. V.	2	2	9			
Journal, Vol. VI.	0	10	6			
Journal, Vol. VII.	2	13	5			
Journal, Vol. VIII.	601	0	0			
Journal, Vol. IX.	7	5	6			
				615	9	6
				1563	16	7
Balance at Banker's, Composition received in December after Consols shut, to be invested				31	10	0
				1595	6	7
Balance at Banker's, Dec. 31, 1852	268	12	7			
Balance in Clerk's hands	21	9	5			
				290	2	0
				£1885	8	7

ESTIMATES *for the Year* 1853.

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Account due by Messrs. Longman and Co. in June, on Journal, Vol. VIII.				54	17	1
Due for Subscriptions on Quarterly Journal				31	10	0
Arrears (See Valuation-sheet)				90	6	0
Ordinary Income for 1853 estimated :						
Annual Contributions (200 Fellows)				630	0	0
Admission Fees :						
Residents (6)	37	16	0			
Non-residents (8)	84	0	0			
				121	16	0
Dividends on 3 per Cent. Consols				113	0	0
Sale of Transactions, Proceedings, and Catalogue				10	0	0
Sale of Quarterly Journal				240	0	0
				£1291	9	1

L. HORNER, Treas. pro tem.

Jan. 31, 1853.

EXPENDITURE ESTIMATED.

	£	s.	d.	£	s.	d.
General Expenditure :						
Taxes	22	9	6			
Fire Insurance	3	0	0			
House Repairs	10	0	0			
Furniture Repairs	15	0	0			
New Furniture	20	0	0			
Fuel	35	0	0			
Light	35	0	0			
Miscellaneous House Expenses	46	0	0			
Stationery	20	0	0			
Miscellaneous Printing	20	0	0			
Tea for Meetings	22	0	0			
				248	9	6
Salaries and Wages :						
Assistant Secretary	200	0	0			
Clerk	120	0	0			
Porter	80	0	0			
House Maid	33	4	0			
Occasional Attendants	10	0	0			
Collector	20	0	0			
				463	4	0
Library, Binding and Additions				50	0	0
Museum				5	0	0
Diagrams at Meetings				15	0	0
Miscellaneous Scientific Expenses				15	0	0
Publications, Quarterly Journal				420	0	0
,, Transactions, &c.				20	0	0
Balance in favour of the Society				54	15	7
				£1291	9	1

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

18th FEBRUARY, 1853.

Award of the Wollaston Medal and Donation Fund.

The President, on delivering to Sir Roderick I. Murchison the Wollaston Medals awarded to M. d'Archiac and M. de Verneuil, addressed him as follows:—

Sir Roderick I. Murchison,—I have to request you to transmit to M. le Vicomte d'Archiac and to M. de Verneuil the two Wollaston Medals which have this year been awarded to them by the Council of the Society, "for their numerous valuable contributions to Geology, and especially for their joint Memoir *On the Palæozoic Fossils of the Rhenish Provinces*, &c., published in the Transactions of the Society." It is unnecessary for me to enter into any detailed enumeration of the extensive and well-known labours of these distinguished geologists, but it would be unbecoming the occasion if I were not to make some brief allusion to them. The researches of M. d'Archiac have extended over a wide geological range. They form the subjects of numerous memoirs, among which I may particularize those on the Cretaceous formations; his "*Essai sur les Correlations des Terrains Tertiaires du Nord de la France, de la Belgique et de l'Angleterre;*" and his "*Description géologique du Département de l'Aisne.*" The excellent memoir written in conjunction with M. de Verneuil, and published in our own Transactions, "*On the Fossils of the Older Deposits of the Rhenish Provinces,*" is particularly noticed in the award. This memoir, with several others, written conjointly by these eminent fellow-labourers, adds to the justice of the simultaneous awards of these medals the gracefulness of propriety. To these valuable contributions, we must add his History of the Recent Progress of Geology—a work equally well timed and well executed. The author has brought to a task,—not unfrequently a difficult and delicate one,—a rare combination of qualifications,—extensive and accurate knowledge of an immense mass of geological memoirs, and great discrimination in the selection of their more important points, united with a sound and impartial judgment in the comparison of the views of different geologists. The result has been a work such that no geological library can be complete without it.

It is well, that while some geologists are engaged in the minute and detailed examination of particular and limited districts, others

should extend their researches over wider areas, with the view of eliciting laws of greater generality than those which more limited regions could afford. Few palæontologists are so well qualified for this difficult task as M. de Verneuil. His accurate and comprehensive palæontological knowledge has enabled him at once to embrace the facts supplied by a new region, and to compare them with those of other regions with which he was previously acquainted. Every geologist is aware of his valuable palæontological contributions to your own able and elaborate work on the geology of Russia. He has more recently devoted himself to an examination of the palæozoic rocks of North America, and to a careful coordination of those rocks and their organic contents with their equivalents in Western Europe,—a task which he has executed to the great and general satisfaction of geologists on both sides of the Atlantic. It is in great works like this, which are only to be executed by men possessing the high qualifications of M. de Verneuil, that the palæontologist rises above the minuter details of his science to the contemplation and establishment of those profoundly interesting laws which the Almighty Creator of the universe has appointed for the distribution and government of organic life on the surface of our planet from the earliest periods of geological record. During the last five years M. de Verneuil has been pursuing his geological researches, with characteristic energy, among the rugged sierras of Spain,—a country likely to prove as interesting to the geologist as it has so long been to the historian and the artist. It is to him that we owe the first outline of a geological map of that country, the approximate accuracy of which may be relied upon.

However scientific men of all countries may recognize the universal tie of scientific brotherhood, it is natural, and, we may add, it is right, that the satisfaction we feel in each advance of science should not be altogether independent of our feelings of nationality and patriotism. We may rejoice in the discovery of every new scientific truth, and we may rejoice the more when we can claim it for our own country. Sometimes, however, the names of scientific men of other countries will become so familiar to us, and such men will become so closely associated with all our thoughts of scientific progress, that feelings of nationality almost cease to influence the pleasure we feel in contemplating their success. M. d'Archiac has become, as it were, the familiar inmate of almost every geological library, and M. de Verneuil, by his intimate geological association with yourself, is regarded by us with almost the same feeling as if he were united to us by the ties of country as well as by those of science. I cannot but regard it, Sir, as a felicitous circumstance that the duty of transmitting to your friend this testimony of our high esteem should so appropriately have devolved upon yourself. I may request you, not only in the name of the Council, but also in that of the whole Society, to assure both M. d'Archiac and M. de Verneuil that we rejoice, not less than their own countrymen, in the well-merited reputation which they have gained by these scientific labours. We trust that they will

regard the awards of these medals as the expression of this feeling, and of the high sense we entertain of the services which they have rendered to geological science.

Sir Roderick Murchison replied in these words:—

Sir,—Being charged by my friends M. d'Archiac and M. de Verneuil to receive for them the Wollaston Medals which the Council of the Geological Society has awarded to them, I have to return to you their warmest thanks, and to express the gratitude they feel for having been honoured by a distinction which is justly so much prized by geologists of all nations.

They also beg me to state, that each of them is deeply touched by the delicacy of that sentiment by which the Council has not shown any preference of one over the other labourer. For whatever, Sir, may be the amount to which jealousies extend in other departments of science, it rejoices me to recognize the absence of this feeling among geologists; and allow me to say, that if ever there were two persons of our craft completely exempt from such a passion, they are the men whom you have just honoured;—their only rivalry having been shown in efforts, whether made conjointly or independently, by which they have advanced our common science.

The extent to which they have done so has been so clearly stated by yourself, that I have only to thank you for having perfectly delineated the nature of merits with which most of our associates are well acquainted.

And here let me explain why our Medallists are not present; now that the Channel is, as it is said, "bridged by steam." Easy as the transit may seem to Englishmen, M. d'Archiac assures me, that the "maladie de mer" which he suffered on the only occasion on which he encountered it, to inspect our cliffs and natural sections, was very great; but great as it might have been, he would have braved it, even at this inclement season, had he not been deeply engaged in the last pages of a work on the Nummulites of India, in which a general view will be taken of the eocene rocks of the East, and specially of the genera and species of those Foraminifera, all over the world,—a work which I trust every English geologist and palæontologist will procure; for in it, M. d'Archiac is, I know, describing and beautifully illustrating the fossils so largely collected by our countryman and contemporary, Major Vicary, in Beloochistan, the Punjaub, and the flanks of the Himalaya.

As to my valued friend and fellow-traveller, M. de Verneuil, he would certainly have been present had not an event occurred in the last ten days which has entirely checked his purpose. Though often before now urged by his friends to solicit the place of Member in the Institute of France, M. de Verneuil has hitherto refused. Recently, however, the place of a free member having fallen vacant, he was persuaded to allow himself to be put in nomination.

Even on this occasion his modesty would have induced him to retire from a conflict singularly painful to him, from the circumstance that according to the habits of his country he must personally

canvass the electors, had not his proposers, M. Elie de Beaumont and M. Dufrenoy, urged him to persevere, even though among his opponents is numbered the distinguished scientific artillery officer, Marshal Vaillant.

In returning you thanks on the part of M. d'Archiac and M. de Verneuil, allow me to add, that no honour offered to myself could have more truly gratified me, than the adjudication of the Wollaston Medal to geologists whose attainments I so highly esteem, and for whom I have so sincere a personal regard.

On delivering to the Secretary the Proceeds of the Wollaston Fund, the President addressed him as follows:—

Mr. Hamilton,—I have to request that you will transmit to M. de Koninck the proceeds of the Wollaston Fund for the present year, which have been awarded to that distinguished palæontologist "in consideration of his many valuable works on Palæontology, and in order to assist him in the publication of his work on Encrinites now in progress." Geologists are deeply indebted to M. de Koninck for the numerous and able palæontological works which he has published during the last twenty years, and it is with more than ordinary satisfaction that the Council have made this award. We could wish that the sum we are able to present to him were such as to afford him more effectual aid in the prosecution of the work in which he is understood to be engaged, but we trust that it will not be the less regarded by him as an indication of the high appreciation in which we hold his palæontological labours.

Mr. Hamilton stated that he should have great satisfaction in forwarding to M. de Koninck the award of the Council, and begged leave in the name of M. de Koninck to return thanks to the Council for the honour thus shown to him,—an honour which, irrespectively of the amount of the award, he was certain would be highly valued by M. de Koninck as a proof of the high estimation in which his geological labours were held by this Society.

ANNIVERSARY ADDRESS OF THE PRESIDENT.

Gentlemen,—On the list of those Fellows of our Society whose death during the past year we have to lament, stands first the distinguished name of

Gideon Algernon Mantell, LL.D., Member of many learned Societies at home and abroad,—who was a memorable instance of a man of genius, constantly and diligently occupied with the practice of a laborious profession, nevertheless reaching great eminence as a man of science, and finding time, even in the midst of pressing duties, to pursue his favourite studies with distinguished success. For several years he practised as a medical man at Lewes in Sussex, in a district which he has rendered classical by his researches into its geological structure. There he collected a vast number of interesting

fossils, and formed a private museum, such as has rarely if ever been equalled. In the year 1835 he removed to Brighton, and four years afterwards from thence to Clapham, near London. At the time of his death he resided in Chester Square. When at Lewes, he published his principal separate works, "The Illustrations of the Geology of Sussex," and "The Fossils of the South Downs." The latter work, which was first in point of date (1822), appeared simultaneously with that of Cuvier and Brongniart upon the Geology of the Environs of Paris, and many of the organic remains of the Chalk were described in both works simultaneously and independently. Whilst at Lewes he called attention to the interest and beauty of the remains of fishes found in the Chalk, and it was there that he commenced the series of observations which placed him in a prominent position among British geologists.

The attention of Dr. Mantell was early directed to the phænomena exhibited by the strata of the Wealden formation. His most important discoveries sprang out of the researches which he never ceased to pursue amongst this his favourite group of rocks. At the time of his death he was occupied with the preparation of a work intended to embrace a general *resumé* of all that had been done about and among them at home and abroad. His location at an early period of his professional career was exceedingly favourable for these inquiries. He was assuredly the original demonstrator of the fresh-water origin of the mass of Wealden beds,—a great step in British geology. His observation of the conditions under which existing fresh-water shells and other bodies of fluviatile origin were imbedded in the alluvium of the valley of the Ouse, and even alternated with marine exuviæ, suggested the probability of the occurrence of similar, but infinitely more ancient, phænomena in the clays and sands of the Weald, and careful research fully confirmed his conjectures. With the Wealden, too, are connected his chief and very memorable palæontological discoveries. Out of that formation he procured the most interesting of the relics of prodigious extinct reptiles, which owe to him their scientific appellations, and whose remains will long constitute some of the chief attractions of the great collection originally amassed by him, and now displayed in the galleries of the British Museum. Whether we regard his discovery and demonstration of the *Iguanodon* and its colossal allies in a geological point of view, as characterizing distinctly an epoch in time, or, with respect to their zoological value, as filling up great gaps in the series of Vertebrata and elucidating the organization of a lost order of reptiles, at once highest in its class and most wonderful, we must, as geologists and naturalists, feel that a large debt of gratitude is due to the indefatigable and enthusiastic man, out of whose labours this knowledge arose. In the group of Dinosaurian reptiles were some of the largest of terrestrial animals. In their organization, whilst truly reptilian, they approached the mammalian type. Their characters were so peculiar, that of the value and distinctness of their order there can be no question. Their osteology has been elaborated with skill and care,

and has worthily occupied the attention of the most eminent anatomists. They give a feature to the herpetology of the middle portion of the Secondary epoch. Now, of the five marked genera constituting this group, as at present known, we owe the discovery and demonstration of four, viz. *Iguanodon*, *Hylæosaurus*, *Pelorosaurus*, and *Regnosaurus*, to Dr. Mantell. Worthily then was the Wollaston Medal and Fund adjudged to our lamented colleague in 1835, "for his long-continued labours in the comparative anatomy of fossils; especially for the discovery of two genera of fossil reptiles, *Iguanodon* and *Hylæosaurus*." That he did not rest from his labours, after having received this honourable reward, the discovery of two additional genera mentioned above can testify. Nor did he cease from continually seeking to perfect his knowledge of the wonderful animals brought to light during his earlier career. Thus, whilst the announcement of the *Iguanodon* dates as far back as 1825, his account of the jaw of this reptile was given to the world fifteen years afterwards. His Paper on *Pelorosaurus* in the Philosophical Transactions was published in 1850. From the Royal Society he received the Royal Medal in 1849, as a just acknowledgement of his palæontological researches.

Dr. Mantell was equally interested in all other branches of palæontology. One of his earliest papers was that concerning the bodies called by him and now well known as *Ventriculites*, found in the Chalk, and referred by him to *Alcyonia*. On Fossil Mollusca and Radiata he wrote many valuable papers, especially those that concern the *Belemnites* and their allies. He was the first to call attention to the preservation of traces of the animals of *Foraminifera* in chalk-flints, and he devoted much time to the investigation of these microscopic bodies. He was an expert microscopist, and possessed fine instruments (one especially presented to him as a testimonial of esteem when he resided at Clapham) and an extensive collection of preparations. He was also much interested in fossil botany, and published several papers on the remains of plants in the Wealden and Cretaceous formations.

Among his most recent labours was the account of the remarkable reptile from the Old Red Sandstone, named by him *Telerpeton Elginense*, an animal of singular interest, since it must be regarded as the most ancient unquestionable relic of its class hitherto discovered. At the time he died he was occupied with a description of a very singular fish from the chalk, to which he intended to give the name of *Rhynchonichthys*.

His labours were not confined to the fossils of his own country. He did much towards making known remarkable fossils from North America and from New Zealand,—countries in which his sons are worthily walking in the footsteps of their distinguished father.

Dr. Mantell's influence in science did not, however, wholly, or perhaps chiefly, depend upon his original researches. As a popular expounder of geological facts, he was unequalled. As a lecturer, he had no rival;—fluent, clear, eloquent, and elegantly discursive, he riveted the attention of his audience, and invariably left them

imbued with a love for the science he had taught them. His popular writings, of which 'The Wonders of Geology' and the 'Medals of Creation' are among the more useful, had a wide circulation, and are held in high esteem by general readers. The works just mentioned have a considerable reputation on the continent as well as in England, and have been translated into German. One of them, the 'Medals of Creation,' is almost the only book in the English language, in which a general survey of the extent of the fossil world, and an interesting outline of British palæontology, can be met with. No fewer than sixty-seven works and memoirs, of various degrees of length and importance, are enumerated in the 'Bibliographia Zoologiæ et Geologiæ' as having proceeded from his pen. These are all upon different subjects of geological or natural history interest; but besides these, he wrote not a few antiquarian papers, and some professional disquisitions of value.

For many years Dr. Mantell endured severe illness and excruciating bodily pain, owing to a spinal disease, the result of an accident. But no torture could destroy his love for science, and his energetic pursuit of geological research. Almost to the hour of his death he was actively occupied with scientific investigations. When once absorbed in an important inquiry, he spared neither expense nor pains in his pursuit after the truth, and, by his enthusiastic and glowing descriptions of his progress, excited all with whom he came in contact to assist in the work.

Dr. Mantell died in his sixty-fourth year.

We have also to regret the death of our excellent Treasurer, Mr. Prevost, who died at Geneva on the 4th of last November. He was born at that place the 27th of June, 1796, and was originally intended by his father, Professor Prevost, for literary or scientific occupations; but political events appear to have led to his coming over to this country in 1814, to devote himself to commercial pursuits. In 1818 he was appointed Vice-Consul of the Swiss Confederation in London, and, in 1830, succeeded his brother, Mr. Alex. Prevost, in the office of Consul General. In commercial life, his simplicity, integrity, and delicate feeling of honour, placed him in the highest estimation. In the promotion and early establishment of railways, he took an active and influential part, and was for many years a Director of the North-Western Railway. He was one of the Council of University College, an Honorary Member of the Society of Arts at Geneva, and many years a Fellow of this Society, of which he was made Treasurer in 1843.

Though diverted at an early period of his life from any systematic cultivation of literature and science, he always preserved, in the midst of more active pursuits, his natural taste for them. In private life, his unaffected simplicity of character and amiable manners rendered him very much beloved. We know how much he was valued by his intimate friends in this country; and a short obituary notice of him in the *Journal de Genève*, written by Professor de la Rive in a tone

of the most affectionate regard, shows the esteem in which he was held by his own countrymen. Those also, whose acquaintance with him was less intimate, will feel the loss we have sustained in our social intercourse, while the Society has lost an officer ever punctual and exact in the performance of his duty.

Major-General Thomas F. Colby, Royal Engineers, LL.D., F.R.S.L. and E., F.R.A.S., M.R.I.A., died October 2nd, 1852, at Liverpool, in the sixty-ninth year of his age. General Colby was the son of Major Thomas Colby of the Royal Marines, and grandson of Mr. Colby of Rhosy-Gilwin in South Wales, a gentleman of considerable property. His maternal uncle was General Hadden, Surveyor-General of the Ordnance. He received his early education at Northfleet School under Dr. Crockell, and was thence transferred to the Royal Military Academy, Woolwich. At the early age of seventeen years and three months, he received his first commission as a Lieutenant of Royal Engineers, and only one month afterwards, in January 1802, was appointed to the Trigonometrical Survey, on the application of Captain Mudge of the Royal Artillery, then Superintendent of that work. Though so young, he at once took part in all the most important operations of the Survey; and when, in 1809, Colonel Mudge became Lieutenant-Governor of the R.M. Academy, and was no longer able to give his undivided attention to the progress of the work, Captain Colby performed all the duties of his executive Officer, both in the Map Office and in the Observatory, with an energy and ability which called forth from Colonel Mudge the warmest expressions of gratitude and confidence. In 1820, on the death of General Mudge, Captain Colby succeeded him as Superintendent of the Survey by the appointment of the Duke of Wellington, who, on this occasion, took the wise precaution of obtaining the opinions of the most eminent scientific men, including the President of the Royal Society, on the fitness of Captain Colby to fill so important an office. In 1824 the superintendence of the Irish Survey was also entrusted to him, and it was then that Major Colby invented and had constructed the *Compensation Bars* for measuring the initial base of that Survey on the shore of Lough Foyle in the North of Ireland. Similar bars constructed also by Troughton, and on exactly the same model, were afterwards used by Colonel Everest in the East Indies to verify some of the old, and to measure new bases, whilst the Irish bars were carried out to the Cape, and there used by Maclear for measuring a base as the commencement of a new arc of the meridian in S. Africa, so that Captain Colby's compensation bars have already been employed and found effective in three great geodesical operations. The arrangements of the Irish Survey were very different from those of the English work, as the object to be attained was also widely different, namely to prepare maps of a scale sufficiently large to become the basis of a Government valuation of land for local taxation. General Colby for this purpose adopted the scale of 6 inches to a mile, and, following the example of Sir William Petty in the celebrated Down Survey, proposed the employment of trained

soldiers, a proposition which led to the formation and instruction of three companies of Royal Sappers and Miners expressly for that duty. The instructions for this work drawn up by General Colby exhibit a remarkable combination of enlarged principles and minute details; and the result of their application, after the first difficulties consequent on the employment of so many newly-formed surveyors had been overcome, was the most perfect success. In 1846, when the Irish Survey may be said to have been completed in all its practical objects, General Colby, on his promotion to the rank of Major-General, was succeeded by Lieutenant-Colonel Hall of the Royal Engineers in the charge of a work with which General Colby had been connected for more than forty years. As regards the Geological Society, General Colby has many claims upon its attention. He was one of its earliest members; he advocated warmly the project, first suggested by Playfair, of combining a mineralogical survey with the topographical one, which led to the appointment of Dr. M'Culloch in connection with the triangulation of Scotland, and therefore to his geological, or, more properly, mineralogical, examination of that country. He gave his opinion, when consulted by the Master General of the Ordnance, decidedly in favour of the publication, by the Ordnance, of Sir Henry de la Beche's geological inquiries in Devon and Cornwall,—a work from which has sprung the present great National Geological Survey; and he even anticipated that work by commencing in Ireland a Geological Survey, comprising likewise researches into the antiquities, statistics, and natural history of that country; his original report in 1824, on the proper objects of a Survey, having laid down the philosophical principle that a great topographical survey was the natural and proper basis for all those collateral inquiries into the mineral and other resources of a country on which its prosperity must so materially depend. As a man, General Colby was remarkable for great simplicity of character, and for a generous disposition which led him too often to neglect the means of ensuring his own fame, whilst he was always prompt in setting forth the merits of those who served with, and acted under him. He was cordially hospitable to his officers, most affectionate to his family, and to his poorer fellow-creatures unostentatiously charitable.

Dr. Thomas Thomson was born on the 12th of April, 1773, at Crief. He received a good classical education at the Borough School at Stirling, and afterwards obtained a Scholarship at St. Andrews in 1787, which entitled him to board and lodging in that University for three years. In 1795 he went to Edinburgh for the purpose of prosecuting his medical studies, and there attended the chemical lectures of Dr. Black, and laid the foundations of his future eminence as a chemist. He graduated in 1799. After having lectured on chemistry for some years in Edinburgh, he was appointed Lecturer in Chemistry in the University of Glasgow, and in the following year the Lectureship was converted into a Regius Professorship, which he held during the remainder of his life. He died on the 2nd of July last, in the 80th year of his age.

I am not aware that Dr. Thomson wrote anything bearing directly on geology. His collection of minerals, now in possession of his nephew Dr. R. D. Thomson, is, I understand, one of the most complete ever made; but his original researches were entirely chemical. His contributions to that branch of science were numerous, and justly obtained for him that high reputation which he lived so many years to enjoy. I may also add that he was the first convert to Dalton's *Atomic Theory*, and one of its most zealous promoters. As a journalist, also, science is indebted to him for the establishment of the *Annals of Philosophy*, which still continues, under the name of the 'Philosophical Magazine,' and under the able direction of Mr. Richard Taylor, to be one of our leading scientific journals.

The number of geological subjects, Gentlemen, which present themselves for discussion is become so great, that an appropriate selection for an occasion like the present is not without its difficulty. The principal subject on which I shall address you is one which has been suggested to me, independently, by several of the most distinguished members of our Society. You are all aware that M. Elie de Beaumont put forth many years ago his theory of the parallelism of mountain chains of contemporaneous elevation. His original views have been expanded from time to time, and have received their most complete development in a work very recently published by him, under the title of *Notice sur les Systèmes de Montagnes* *. It contains a large amount of mathematical investigation, which renders a great portion of it inaccessible to readers who do not possess a thorough acquaintance with geometry; and the general arrangement of the work, though well calculated to give a complete development of the author's views, is such as to make it sometimes difficult to appreciate the exact value of his evidence in support of them without a careful examination of numerous details. The whole is worked out with great ingenuity, a perfect acquaintance with the mathematics of the subject, and with that unflinching perseverance and honesty, if I may so speak, which have left none of the intricacies of his problem without a thorough investigation. The theory which he maintains exercises, as you are aware, a wide influence over the rising geologists of France, and has also been accepted to a considerable extent by other continental geologists; and whatever may be the degree in which it may have a claim to our confidence, every geologist ought to be acquainted with it, if he would make himself fully conversant with the existing state of the science. I have thought, therefore, that I could not on the present occasion render a more acceptable service to the Society than by laying before you as complete an analysis of M. E. de Beaumont's work as I am able to make, and such as shall not only make you acquainted with the conclusions of his theory, but may also enable you to appreciate for yourselves the evidence on which it rests.

I must first request your attention to a few preliminary points.

* Three vols. 12mo. Paris 1852.

In considering the nature and relative positions of lines drawn on the surface of a sphere, we may regard them as straight or curved, as parallel or inclined to each other at certain angles, in the same sense in which we should speak of such lines drawn on a surface accurately *plane*, provided the extent of the surface on which these lines are situated be so small compared with the surface of the whole sphere, that we may neglect the *curvature* of this small portion of the spherical surface without committing an error large enough to be of importance in the final results of our investigations. Thus, in speaking of the parallelism of any phænomena of elevation in a particular geological district, it would only be an absurd affectation of accuracy to regard such lines as drawn on the *spherical* surface of the earth in contradistinction to their being drawn on a *plane* surface, though it might be absolutely necessary to make the distinction with reference to the refined exactness of a trigonometrical survey. In such limited regions the term *parallelism* may receive its ordinary definition without sensibly affecting any degree of accuracy to which geological investigation or observation can aspire. But, on the contrary, when we speak of lines on the earth's surface distant from each other by many degrees of latitude and longitude, we can no longer, even in an approximate sense, consider them as straight lines drawn on a plane surface, and consequently the term *parallelism*, which, in its strict definition, is applicable only to *straight* lines, can no longer be applied except under some modified definition of the expression. It is absolutely necessary to understand the exact sense in which M. Elie de Beaumont makes use of this term. To explain it, I shall first give the definitions of a few elementary terms of constant occurrence in the geometry of the sphere. In doing this I may appear perhaps to be assuming an ignorance on points with which the majority of my hearers are well acquainted; but I think it better not to incur the risk of using terms in any part of my exposition of this theory, which might convey erroneous, or at least indefinite conceptions to the mind of any geologist who may wish to make himself acquainted with it.

Suppose we make a number of sections of a sphere by a set of planes all parallel to each other, and one of which passes through the centre of the sphere. The section of the surface of the sphere made by this latter plane will be a circle which will manifestly divide the whole surface of the sphere into two *equal* portions. Such a circle is termed a *great circle* of the sphere. The sections of the surface of the sphere formed by the other planes of the set abovementioned will also be circles, but such as will divide the whole surface of the sphere into two *unequal* portions. All such circles are called *small circles*. Thus we have a set or system of *small circles*, indefinite in number, corresponding to each *great circle*, and all having a certain kind of *parallelism* to each other depending on the fact of the planes by which they are formed being *parallel* to each other in the strict geometrical acceptation of the term. It is on this kind of parallelism of one of these circles to another, that the definition of the term, as used by M. Elie de Beaumont, is founded.

As the centre of a circle is equidistant from every point in its circumference, so is there a point on the surface of the sphere equidistant from every point of a *great circle* of the sphere. There are, in fact, two such points at opposite extremities of that diameter of the sphere which is perpendicular to the plane of the great circle. Each of these points is also equidistant from every point in the circumference of any *small circle*, whose plane is parallel to that of the great circle. These two diametrically opposite points are called the *poles* of the great circle, from every point of which they are equidistant. They may in like manner be termed the *poles* of all the corresponding small circles, the only difference being that the same small circle is not, as in the case of a great circle, equidistant from each of its poles. The equator and the small circles parallel to it, as represented on a common terrestrial globe, offer an example, familiar to every one, of a *system* of circles like that I have described, the poles of the earth being in this case the poles of the system.

We may observe that the position of the pole of a great circle determines that of the great circle itself, as the pole of the earth determines the position of the equator. The position of a *system* of small circles is determined by that of its great circle, or, therefore, by that of its pole. The position of each individual small circle is not completely determined by that of its pole, since its distance from the pole remains undetermined.

If we draw a great circle through the two poles of our system, it will cut not only the great circle, but also every small circle of the system at right angles. A number of such circles are represented on common globes for the purpose of showing the longitudes of different places. Conversely (and this should be carefully noted) if we draw a great circle perpendicular to a great or small circle of the same system, it must necessarily pass through the pole of the system. Hence we have an obvious way of finding the pole of a system when any one of its circles is given; for if we draw two great circles through two different points of the given circle, each being perpendicular to it, then, since each must pass through the pole of the system, that pole must necessarily be the point of intersection of those great circles. Moreover the pole being known, the great circle of the system is known, being that circle every point of which is distant from the pole by 90° measured along a great circle drawn through the pole. Hence, if, at any given point of a sphere, we know the direction of a small circle belonging to a particular system, so as to be able to draw a great circle perpendicular to it; and at another given point, we know the direction of the same or of any other small circle belonging to the same system, we can at once determine the position of the pole and great circle of the whole system; for we have only to draw two great circles respectively perpendicular to the two given directions of the small circles, and the intersection of these great circles determines the pole, and thence the great circle of the system. A distinct conception of this simple method is essential to the understanding of the theory which I am about to explain. If absolute accuracy were required, the position of the pole must be

determined by mathematical calculation founded on the above or some equivalent reasoning; but where less accuracy is required, the process above indicated may be *graphically* performed on a common globe, so as to determine the position of the pole with sufficient exactness.

It will further be necessary for us to consider one or two points concerning the relations in which two such systems as I have described stand to each other. Since the planes of their respective great circles both pass through the centre of the sphere, they must intersect along a diameter of the sphere, and the circles themselves must intersect each other at the two extremities of that diameter. Either of these points of intersection is one of the elements by which the position of one of these great circles may be determined with respect to the other. The second element is the angle at which they intersect. If these two elements—one of the points of intersection, and the angle of intersection—be known, the relative positions of the two great circles, or of the two corresponding systems of small circles, are completely determined. These relative positions may also be expressed by that of the poles of the two systems, but the above is probably more easily conceived.

The great circle representing the ecliptic on ordinary terrestrial globes, and the small circles parallel to it (usually represented on celestial globes), afford a familiar example of a second system of small circles. The points representing the equinoxes are the points of intersection. It will also be observed that the ecliptic *touches* the two small circles which represent the *tropics*, but without intersecting them, and at equal distances (90°) from the equinoxes. It is also easily seen that the *directions* of the great and the small circles at their common point of contact will be identical; in other words, the straight line which is a *tangent* to the one at that point will also be a tangent to the other. This fact may also be stated in another way:—if we take a very small arc, a portion of the great circle, the middle point of that arc being the point of contact, and a similar equally small arc of the small circle, these two small arcs will be very approximately coincident, and may be considered so for all practical purposes with which we are here concerned.

The propositions which have here been stated with reference to a particular point of a particular small circle, are equally true for every point of every small circle; for a great circle can be drawn so as to *touch* without *intersecting* any small circle belonging to any system at any proposed point, and this point of contact will necessarily be 90° from either point of intersection of this great circle with that of the system to which the small circle thus touched belongs.

We may now distinctly explain the modified sense in which our author uses the term *parallelism* as applied to mountain chains or other lines of elevation situated on any part of the earth's surface. Every such line is considered as a portion of a *great circle*, but is in general so short that it may be regarded as coinciding with the *tangent* to its middle point, or with a *small circle* having the same tangent at that point, in the same manner as the great circle repre-

senting the ecliptic coincides with the small circle representing either of the tropics, for a very small space on either side of the point of contact. The line of elevation may therefore be considered as belonging to the same system of small circles, as that small circle with which it coincides. Any other lines of elevation belonging in like sense to the same system of small circles as the first-mentioned line, are said to be *parallel* to it. All these lines will be parallel to the same great circle—that of the system of small circles to which they all belong, and are said to constitute a *parallel system* of such lines. This great circle is of the first importance in our author's theory. He has called it *le grand cercle de comparaison*. I shall term it the *great circle of reference*. It defines the *characteristic direction* of each *system* of mountain chains or other lines of elevation.

I have already said that each line of elevation is considered strictly as a portion of a *great circle*, and only approximately as a portion of a *small circle*, and that too when the line itself is sufficiently short. Were we at liberty to speak of them as really portions of small circles, we might more simply define a parallel system as consisting of lines every one of which was parallel to one and the same great circle, in the same sense as that in which a small circle is said to be parallel to the great circle of its system. This definition, though only approximate, does really convey the essential notion of a parallel system of lines of elevation, so far as it forms the basis of the actual investigations of M. E. de Beaumont, the greater part of which lead to results which, though having all the accuracy which the nature of the subject can possibly require, are still, strictly speaking, only approximate*.

We are now prepared to enunciate the two general propositions of M. E. de Beaumont's theory. *The first asserts generally the parallelism of lines of elevation of contemporaneous origin*; *and the second asserts the existence of certain symmetrical relations between the great circles of reference of those different parallel systems.* The term *contemporaneous* is interpreted, I believe, by our author in its strict and literal sense, as indicating one great effort of the elevating forces, and not a succession of minor efforts during a determinate and comparatively short geological period. The nature of the *symmetrical relations* above spoken of will be explained when I come to the explanation of the second part of this theory.

Let us now proceed to the application of the preceding considerations. Suppose we have any number of lines of elevation, such as mountain chains, anticlinal and synclinal ridges and valleys, faults, &c., the position of each line being known by the latitude and longitude of its middle point, and the angle which it makes with the meridian at that point, *i. e.* the point of the compass to which it is

* If through the middle points of any number of lines of elevation, we draw great circles perpendicular to those lines respectively, and these perpendiculars all meet one and the same great circle at right angles, then will the lines of elevation be parallel to each other. This is the way in which our author defines a system of *parallel* lines. It is manifestly equivalent to that given in the text. The one great circle to which all the others are perpendicular is the *great circle of reference of the system.*

directed. Our object is to ascertain whether these lines can be grouped into *parallel systems*, and if so, to determine the *great circle of reference* of each system. If we wish to construct these great circles by the graphical method, we must proceed as already indicated. We must mark these lines with great care on a terrestrial globe, and then through their middle points draw great circles respectively perpendicular to them. Supposing this operation to be performed with perfect accuracy, and the given lines to belong to a certain number of parallel systems, that fact would appear by the accurate convergence of the great circles perpendicular to the respective lines all converging to a certain number of points, each of which would be the pole of the corresponding system of lines. These poles being thus determined, the corresponding *great circles of reference* are immediately known.

In actual practice it would be impossible to perform this operation with absolute accuracy, and the consequence would be that the great circles which ought to converge exactly to the respective poles of the different systems would only pass near to them, and thus by their mutual intersections would indicate approximately the positions of the poles, instead of determining them with perfect precision.

Instead of adopting this graphical method, we might proceed by actual calculation from the data above stated; and in doing this, we might either adopt methods which would give us results of mathematical accuracy, or those which give only approximate results, but still of sufficient accuracy for all the purposes we have in view. These latter methods, being in general infinitely more simple than the exact methods, are those usually adopted in all complicated geometrical and physical researches, and have been generally followed by the author of the investigations before us.

I have here supposed the given lines of elevation to be capable of being accurately grouped into distinct systems. It is not, however, to be expected that the entire number of such lines, as they exist in nature, should admit of being so grouped into a comparatively small number of *accurately* parallel systems. Whatever, therefore, might be the precision with which our graphical process should be performed, we might still expect that the great circles perpendicular to the given lines of elevation, instead of passing exactly through a certain number of poles, would only pass *near* to them, in the same manner as above described under the supposition of the graphical process being inaccurately performed. In such case each system of lines would have no *exact* pole, and no *exact* great circle of reference.

Another source of indeterminateness in the positions of these circles must necessarily exist in the imperfect determination by observation of the *directions* of the lines of elevation. The possible errors from this cause must probably ever remain considerable, on account of the want of more definite character in many of the phæ-nomena to be observed.

I have hitherto spoken of a grouping of our lines of elevation into separate systems, depending only on the *directions* of those lines. There is also another obvious principle on which we may group

them. We may regard all the lines of which the formation may be referred to a distinct geological period as belonging to one system. The number of such systems would be equal to the number of recognized geological periods of elevation. What may have been the duration of each period of disturbance, it is impossible to determine. We can only show by geological observation, that those periods must have been respectively comprised between epochs defined by particular geological phænomena, and may unquestionably in many cases have been of sufficient duration to admit of a series of many consecutive movements. M. de Beaumont, however, has always, I believe, contended for one great, sudden, and instantaneous movement, which has produced all the phænomena of elevation referable to the period in which it occurred. I confess myself somewhat surprised at his insisting on this point, which is not essential, I conceive, to his mechanical views on the subject, and his theory of parallelism may be as applicable to the result of a succession of movements during a comparatively short definite period, as to the effects of a single movement. Some of the movements might reasonably be supposed to have been sufficiently energetic to stamp at once their impress on the geological character of each district, but I see no adequate reason why the theory should altogether reject the idea of subordinate movements in the same system.

We have next to inquire; are these two groupings of the lines of elevation,—the one depending on the *directions*, the other on the *relative ages* of those lines,—identical with each other? M. de Beaumont replies in the affirmative; and it is on the truth of this assertion that the geological value and importance of his theory depend.

I have already pointed out two essential sources of indeterminateness in the grouping of lines of elevation according to their directions, viz. the actual deviation from exact parallelism in the lines of each system, and the imperfect determination of the actual directions of the lines. We must now, in like manner, consider the essential sources of indeterminateness in the grouping of these lines, according to their relative ages.

If a series of conformable horizontal beds be subjected to an elevatory movement which gives to them a determinate *strike*, the direction of the strike will be that which characterizes the movement. Suppose these beds to be acted on by a second similar movement, which, if the beds were horizontal, would give them a strike (the characteristic direction of this second movement) different from that resulting from the first movement. The actual strike would be intermediate to these two directions, and would not be characteristic of either movement. In all cases in which the last movement materially affecting the configuration of a district was of great magnitude, the effects of all minor anterior movements would be nearly obliterated, and those of greater movements considerably modified. Faults, on account of their approximate verticality, would be generally much less affected in direction by any subsequent move-

ment, than the strike of the moderately inclined beds, and would be the phænomena which might frequently be most depended on for giving the characteristic directions in such cases as those we are speaking of, provided the *longitudinal* could be distinguished from the *transverse* faults.

If the beds, affected as we have here supposed by two successive movements, be in the immediate neighbourhood of other beds affected only by the last movement, and therefore affording a measure of its magnitude and giving its characteristic direction, we can easily eliminate the effects of that movement on the beds affected by both movements. But in regions where we have no such means of analysing the resulting effects, it must be impossible to assign with any accuracy their characteristic directions to the earlier movements. The great disturbance, for example, which broke up the coal-measures in this country, must doubtless have extended far beyond the limits in which we now find coal and the beds associated with it, and must have materially modified the effects of former movements.

All theories of elevation, in their application to the older formations, must be in like manner affected by the difficulty of analysing the effects of successive movements which have disturbed those formations, but they may be affected in very different degrees. In the case before us, we have to consider the importance of this difficulty in a theory, which, even in its present professedly imperfect development, requires the determination of the angular positions of the characteristic lines of elevation, as we shall see in the sequel, with a close approximation to accuracy.

I have here discussed this source of indeterminateness in our author's theory as lying in the difficulty of deducing from existing lines of elevation the characteristic directions of the earlier movements which affected the older rocks at certain *assumed* successive epochs. We may further inquire what is the nature of the evidence in support of the assumption that each group of lines characterized by a particular direction is really to be referred to one particular epoch. Now if you follow carefully the description given by M. de Beaumont, of the systems which he has particularized, you will find instances in which this evidence is independent and satisfactory—those in which a movement has affected any formation without affecting the superincumbent beds. But in other instances, you will observe that lines of elevation are referred to a certain epoch merely because they are parallel to other lines belonging to that epoch, in another and sometimes distant locality. It must not be hence inferred that any confusion on these points exists in the mind of the distinguished author of this theory. He doubtless considers that the number of the first class of the above-mentioned cases—that in which the evidence of the contemporaneity of parallel lines is independent and satisfactory—is sufficient to justify the induction that the mere parallelism of the lines, in the second class of the above cases, is sufficient proof of the contemporaneity of their origin. It is essential, however, for those who would make a critical examina-

tion of this theory, to keep these two classes of cases carefully distinct. The former alone can furnish the evidence on which the theory must rest.

Again, in estimating the force of the induction from these established cases, we must recollect that there are systems of lines of elevation characterized by directions differing widely from each other, but which would appear, at first view at least, to be referable to the same geological period. Such cases will necessarily demand a scrutinizing examination of the evidence on which the assertion of the independence of such systems of lines of elevation is made to rest; for if no geological evidence, independent of the theory itself, can be found for assigning distinct epochs to sets of lines characterized by different directions, the force of induction from those cases where independent evidence does exist of a relation between epoch and direction, will be diminished in a degree proportional to the ratio which the number of exceptional bears to that of the established cases. This, in fact, is the very point on which our acceptance of this part of our author's theory must depend.

I have already remarked that the theory of M. de Beaumont, as now laid before us, consists of two parts:—first, that which asserts the contemporaneity of origin of those lines of elevation which have the same characteristic direction (with the exception of those cases which present *recurrences* of the same direction); and secondly, that part which asserts certain relations of symmetry between the *great circles of reference* which respectively define those characteristic directions. The first part would not require any very accurate estimate of the *limits of error* in the determination of the positions of these great circles, but such an estimate is so important in the discussion of the second part of this theory, that I must here again direct your attention to this point with more especial reference to the European systems described by M. de Beaumont.

Let us then suppose that we have a number of lines which belong *accurately* to one *parallel system*. If through any two of these lines we draw two great circles accurately perpendicular to them (and which, for the greater distinctness, we may suppose to pass through the middle points of the lines), these great circles will intersect in the *pole* of the system to which the lines belong. Suppose the position of one of these two lines to be accurately given, but the other to be determined with a small error, as to its direction. The direction of the great circle perpendicular to it will be affected with an equal error. Now if the angle between the two great circles be large, the consequent error in the position of the point of their intersection will be only small; but if the angle between these two great circles be small, the consequent error in their point of intersection will be comparatively large. The case is exactly analogous to that of two straight lines intersecting each other at a small angle and passing through two fixed points; a small change in the angular position of either line will make a comparatively large change in the position of the point of intersection. Thus, suppose one system of lines to be a real system situated in

the middle and westerly parts of Europe, and let us suppose the determination of the direction of each line of the system, subject to an error of 3°, *i.e.* of $1\frac{1}{2}°$ in excess or defect, the consequent error to which the determination of the pole of the system, by means of any two of these lines, would be liable, might amount to 8° or 10°, though we should select two lines best adapted for this determination; and if we also take account of the actual deviations of the existing lines, from the exact parallelism above assumed, the above error might be much greater still. The *probable* errors would doubtless lie within these extreme limits; but even these errors must necessarily be very considerable, when the determination of the position of the *pole* of the system, or of the *great circle of reference*, depends on lines spread over no larger a portion of the earth's surface than that of Western and Middle Europe. This, I imagine, is the reason why M. de Beaumont has not attempted to determine, by the above or any equivalent method, the positions of the great circles of reference for his European systems. Guided by certain hypothetical considerations, as I shall presently show, he has in each case *assumed* a point through which each of these circles passes, and regards their positions, as at present determined, only *provisional*, to be corrected hereafter when all the component lines of each system shall be more accurately known.

In all the preceding explanations I have made much more use than M. de Beaumont of the *small circles* parallel to each great circle of the sphere, and of their *pole*, believing that I might thus facilitate your accurate conception of the leading points of this theory. Our author, on the contrary, usually appeals to the *great circle of reference* itself rather than to its *pole*. The position of that circle may be determined by the latitude and longitude of its pole; or by the position of a point called *the centre of reduction*, through which the circle passes, and the angle which it makes with the meridian at that point, *i. e.* the point of the compass to which it is there directed. It is this latter method which M. de Beaumont has found it most convenient to adopt, and those who may follow his steps will find the facilities of doing so very much increased by certain tables which he has given for the purpose. And, indeed, we cannot too highly commend the pains which he has taken throughout to secure the accuracy of calculations involving an immense mass of details, and to afford every facility either for the verification of his own results, or for the making of other similar calculations.

Our author has given strictly accurate methods of determining the two elements which fix the position of the *great circle of reference* of any proposed system of lines, viz. the *centre of reduction*, and the *direction* in which the great circle passes through that centre. These methods, however, involve very complicated and laborious calculations, into which it would be useless to enter without more accurate data than we at present possess. The methods which he has actually adopted are such as lead to results of *approximate* accuracy. An exact calculation with imperfect data would only lead to results

having the same degree of indeterminateness as that of the graphical method above explained of determining the *pole* of the proposed system, so far as that indeterminateness depends on the imperfectness of the data. Instead, therefore, of calculating for each system the position of the *centre of reduction* through which its *great circle of reference* passes, our author has, in each of the systems which he has investigated, *assumed* the position of this centre, guided by such considerations as the following:—If the space occupied by a system of parallel lines on the earth's surface were a well-defined zone bounded by two parallel small circles, to which all the lines of the system are parallel, the *great circle of reference* must necessarily be that which is parallel to these bounding small circles. It might be within or without the zone. If the zone were of considerable length, there would be no difficulty in determining its great circle, either by calculation or by the graphical method; but when the given part of the zone is very short (not extending, for instance, beyond Western and Middle Europe) and only approximately known, it will be impossible to determine the exact position of the *complete zone*, or consequently to find, with any very approximate accuracy, the position of its *great circle of reference*. It is here that our author introduces his assumption—*that the zone, in which each actual system of parallel lines of elevation on the earth's surface is comprised, is bisected, or nearly so, by its great circle of reference.* Whether this assumption be true or not, it is impossible to determine, till the systems recognized by M. de Beaumont have been traced over a much greater extent of the earth's surface. There is probably scarcely one of the European systems in which its great circle of reference would not be as good an approximate representative of the direction of the system, as at present, if the centre of reduction, with the circle itself, were moved 8° or 10° from its present position in a direction perpendicular to that of the provisional *circle of reference*.

The great uncertainty which attaches to this method of determining the *centre of reduction* from observations in a limited district, may be elucidated by considerations like the following. Suppose that instead of taking the region of Western and Middle Europe, we should take that of Eastern Europe and Western Asia. Proceeding on the above assumption respecting the *centre of reduction* of each *great circle of reference*, most of those great circles would be made to pass nearly centrally through this new region, instead of being so situated with reference to the former region. This would be a manifest contradiction, supposing always the same parallel systems to exist in both regions. Either of these determinations *might* be right, one of them must be wrong, and probably both would be so. If the directions of the lines of elevation could be *accurately* observed, and were *accurately* parallel, there could be no such contradiction as the above. It is the want of this geometrical accuracy, and the small dimensions of the observed region compared with the area of the complete terrestrial zone, of which it may be considered a portion, which create

the necessity for *assuming* the position of the *centre of reduction* of the *great circles of reference*, and the above example shows the serious error to which such an assumption may possibly lead.

An error of this kind, however, in the provisional determination of the *great circles of reference*, is not of material importance with respect to this first part of M. de Beaumont's theory, because it does not affect the question of the parallelism of systems of lines of contemporaneous origin; but it appears to me to be of vital importance with reference to the evidence which can possibly be at present adduced in support of the second part of our author's theory, because that evidence depends essentially, as we shall see hereafter, on a coincidence of the *great circles of reference* with certain lines of his *réseau pentagonal*, too approximate to admit of the degree of uncertainty above-mentioned in the positions of those great circles. But I shall again return to this point.

Proceeding at present, however, on this assumption, we have only to fix on a point as centrically situated as possible with reference to our given lines of elevation, and to consider that point as the *centre of reduction* through which the required *great circle of reference* must pass. Its position must be defined by its latitude and longitude. The next step is to determine the *direction* in which the *great circle of reference* passes through the *centre of reduction*. For this purpose we have to determine the angle which this great circle must make with the meridian at that point (or the point of the compass to which it is there directed) in order that it may be parallel to any given line of elevation of the proposed system, the position of that line being given by means of the latitude and longitude of its middle point, and the point of the compass to which it is directed. If all the lines were exactly parallel, in the sense in which the term is here used, it would manifestly be immaterial which we should take for the purpose of determining the direction of the above great circle, since each would necessarily give the same result; but in nature this parallelism can only be expected to be approximate. Consequently we must determine the directions of the *great circle of reference* corresponding to each particular line. These directions will be only approximately and not accurately the same, and the *mean* of these directions must be taken, as that which will best represent the great circle of the system.

The different lines of a system characterized by this kind of parallelism, and comprised within a portion of the earth's surface sufficiently small and not too near either of its poles, will be directed sensibly to the same point of the compass; but a little consideration will show us, that such is not the case when the lines are contained in a much larger area. The earth's equator cuts all meridians at a right angle; but any other great circle can only cut *one* of all the terrestrial meridians at right angles, doing so at two diametrically opposite points. At those points the direction of the great circle is exactly east and west. It cuts all the other meridians at angles differing from a right angle, and, consequently, at such points of intersection its direction is not east and west. Similarly small circles

parallel to this great circle will manifestly meet different meridians at different angles, and, therefore, different lines of elevation coinciding in direction with these small circles at different points of the earth's surface, and consequently belonging to the *same parallel system*, must be directed respectively to different points of the compass. The only exception is presented in the system of which the equator is the great circle of reference, in which case every line of the system will meet its meridian at a right angle, or will be directed exactly east and west*.

I will now point out the steps we must take in their logical order, to investigate the truth of this first part of M. de Beaumont's theory.

We must first take all the lines of elevation with which we are acquainted and divide them into two groups—the one containing all those lines which can, on independent geological evidence, be referred to distinct geological epochs of formation, and the other containing those lines for which the evidence is inconclusive. Let the numbers in these two groups be represented respectively by M and *m*. The latter can afford us no fundamental proof of the truth of the theory we are discussing.

The lines in the group M will form systems the number of which will equal that of the recognized geological epochs of elevation, each system being characterized by the contemporaneity of formation of the lines composing it. We must now take each of these systems and ascertain by the methods already indicated, the number of lines in it which may be distinctly grouped into a *parallel system*. Let the number of those, in the whole group M which can be thus arranged in different parallel systems, be denoted by N, and let the remaining lines in M be denoted by n. Then must the value of the fundamental evidence in favour of this theory be found in the proportion which the number N bears to n, or in the value of the ratio $\frac{N}{n}$. Let us consider its interpretation.

Suppose the above-mentioned systems to occupy the surface of the earth generally; then if N be much greater than n, we must infer that each of these systems of parallel lines is due to some cause, the action of which has extended simultaneously to all parts of the earth's surface, and which may be termed *general*, in contradistinction to those causes whose action is *local*. It is to causes of this latter kind that the other lines of elevation (n) are to be attributed. As an example of a *general* cause, we may cite that of the shrinking of the earth's superficial crust, resulting from that of its interior mass by the loss of heat; and volcanic action restricted to a limited space affords an instance of a *local* cause.

If n be much greater than N, there is no longer any distinct indication of the action of a *general* cause in the above extended sense of the term; and the phænomena under consideration must be referred to mere local causes.

If N and n be both considerable, our inference will be that some

* All this will be made very obvious to the eye by simply placing a thread on a common globe so as to form a portion of the arc of any great circle, and observing the angles at which it crosses the different meridians.

general cause has been combined with more *local* causes to produce our lines of elevation; and according as N or n preponderate, we must consider some general or some more local causes to be those to which the phænomena are attributable.

If N be much greater than n, as we first supposed, the theory which asserts that the parallel lines of the same system are of contemporaneous origin may be considered to be so far established, that we may by induction apply it to determine the ages of the lines in group m, of whose age there is no direct conclusive evidence. The final proof of the truth of the whole theory must then be sought in the degree of harmony which pervades it, and the satisfactory manner in which it may account for the general phænomena of elevation.

I have been the more careful in directing your attention to these points, because unless a marked distinction be made between those cases in which the epoch of formation is determined on satisfactory evidence, and those in which the evidence is inconclusive, a very erroneous estimate might be formed of the real amount of evidence in favour of this part of M. de Beaumont's theory.

After having explained the general principles of this first part of his theory, our author proceeds to describe the different parallel systems which, as he conceives, our present knowledge enables us to recognize. Much the greater number are founded on observations made in Europe, and are called *European Systems*, though their extension to other quarters of the globe is regarded as probable. They are twenty-one in number; their names are derived from the following places:—

La Vendée,
Finisterre (Britanny),
Longmynd,
Morbihan (Britanny),
Hundsrück and Westmoreland,
The Ballons (Alsace),
Forez (Department of the Loire),
North of England,
The Netherlands and South Wales,
The Rhine,
Thuringerwald,
The Côte d'Or,
Vercors* (Department of La Drôme),
Mont Viso (French Alps) and Pindus,
The Pyrenees,
Corsica and Sardinia,
Tatra (N. of Hungary),
Sancerrois (France),
The Western Alps,
The principal Chain of the Alps,
Tenara (Prom. of Tanarium, Peloponnesus).

These systems are described, and the evidence on which they rest is given in considerable detail in M. E. de Beaumont's work.

* The relative age of this system is not determined.

The *centre of reduction* of the *great circle of reference* for each system, and its *orientation*, are investigated and determined. I shall not here pursue this descriptive part of the subject, but shall recur to it in the sequel. I proceed now to explain the second part of our author's theory—that which assigns certain relations between these great circles of reference.

Theory of the Réseau Pentagonal.

After having devoted so much attention to his theory of the parallelism of mountain chains of contemporaneous elevation, and the determination of the *great circles of reference*, it was natural to expect that M. de Beaumont would be led to the examination of the relations which might exist between these great circles. He appears to have long had the impression that these relations must be *relations of symmetry*. I know not whence he derived these *à-priori* impressions, but it would seem that they must have amounted almost to conviction, to have induced him to undertake the laborious and intricate calculations which have been necessary to enable him to place his views in the form in which they are now brought before us. And here, Gentlemen, whether we may agree with the views of this distinguished geologist or not, let me claim the highest praise for the candour with which he has developed them. Every step in the process of his investigations has been explicitly stated, and all his numerical calculations appear to have been elaborated with the utmost care; and where their results are only approximate, no pains have been spared to ascertain the probable errors to which they are liable. In these respects he has left nothing in the mathematical part of his investigations to be desired.

After having established the positions of his *great circles of reference*, he was anxious to observe more especially the relations existing between the directions of the great circles of his European systems. For this purpose it was necessary to reduce them all to *one centre*. This was done by drawing a great circle through the proposed *centre* at right angles to any assigned *great circle of reference*, and then drawing another great circle, also through the *centre*, perpendicular to that previously drawn at right angles to the *great circle of reference*. The second circle thus drawn through the centre was *parallel* to the *great circle of reference*, and therefore represented it *in direction* at the *assumed centre*. The circles of reference thus reduced to one centre were represented by lines radiating from that centre, and thus affording convenient means of comparing their respective directions.

Vannes, a town in the north-west of France, was first chosen as the centre, and several great circles having been reduced to that point, instances of approximate parallelism between some of these circles, and of approximate perpendicularity between others, were remarked; while some of the angles appeared to be bisected or trisected by other lines, facts which seemed to indicate a certain degree of symmetry. To examine these and similar facts the more carefully, our author finally chose three different centres—Milford Haven in

S. Wales, Bingerloch on the Rhine, and Corinth,—and reduced all the *great circles of reference* of the European systems to each of these centres. All the lines thus reduced are represented radiating from these centres on three small maps, which thus exhibit at once to the eye the arrangement and grouping of the lines. If the lines to be reduced to these centres were *straight* lines on a *plane* surface, instead of *great circles* on a *spherical* surface, they would manifestly radiate from each centre so as to make exactly the same angles with each other as at the other centres; but, after the reduction of the great circles to these centres, such is not exactly the case, as may be seen by inspection of the maps above mentioned. The differences however are not great. M. de Beaumont was not satisfied to estimate these angles by a graphical method, but calculated, by trigonometrical formulæ, the angles which every radiating line makes with every other for his twenty-one recognized European systems. These angles are tabulated in three separate columns corresponding to the three centres*. He has also added a fourth column, giving *the means of the three preceding*, and a fifth containing the angles at which every *great circle of reference* intersects every other. These angles do not differ much from the former†.

Having obtained all these angles, our author again arranged them in each column according to *order of magnitude*, in a manner of which a specimen is given, p. 876, the whole table thus formed being too long for insertion. He was thus the better able to observe the *intervals* between successive angles so arranged, and remarked that for several successive angles together, in certain parts of each series, the intervals were smaller, and in other parts considerably larger, the former presenting closer *groups*, and the latter wider open spaces (*lacunes*). These *groups* and *lacunes* were again *graphically* represented (in a manner of which a specimen is given in Plate iv.) by horizontal lines drawn across vertical columns, the closer representing those parts of each series of angles contained in the vertical columns of the table just mentioned, in which the *groups* occur, and the open spaces those in which the *lacunes* occur.

It is in these *groups* and *lacunes*, whether studied numerically in the table or graphically in the plate, that our author recognizes, as he conceives, indications of *law* in contradistinction to arrangements which might have resulted from mere *chance*. He especially recognized the fact, that several pairs of *great circles of reference* are inclined to each other respectively at very nearly equal angles. Thus the angle between the system of the Pyrenees and that of the Netherlands is about 22° 14′; between that of Vercors and that of the

* *Op. cit.* p. 840.

† This is due to the circumstance of the *great circles of reference* for the European systems having been so chosen that they must necessarily intersect each other at points in or near the European region, with the exception perhaps of some which intersect at small angles. Consequently the above centres are not generally far from the points of intersection, and hence the differences of direction at those centres do not differ much from the angles of intersection to which they would, of course, be exactly equal if the lines were straight lines on a plane surface.

Longmynd 22° 10′; between that of Forez and that of Vercors 22° 24′, all these systems being referred to Corinth as the *centre of reduction*; and for several other pairs the intervening angle was also found of very nearly the same value*. Hence our author was led to the inference that the great circles of his different systems must probably belong to some symmetrical figure, because in any such figure, as is manifest, it will frequently happen that different pairs of lines are inclined to each other at equal angles. Such evidence of symmetry will doubtless be felt to be extremely vague. It is not, however, to be regarded as a part of the final evidence on which this part of our author's theory is made to rest, but rather as affording him some indistinct and distant view of that symmetry which he appears to have been persuaded must really characterize some system of lines of which his *great circles of reference* formed a part. It was thus that he seems to have been encouraged to proceed with that elaborate series of calculations by which alone his views could be adequately tested.

With these impressions, his first object was to consider the different ways in which the surface of the sphere may be symmetrically divided into a number of parts by great circles. Now every one acquainted with the elements of crystallography will be aware of the usual manner of representing the characteristic lines and angles of crystals by means of the projection of the *crystalline edges* into great circles of an imaginary sphere, whose centre is symmetrically situated with respect to the crystalline faces. In the same manner the edges and angles of any solid figure may be represented. A *regular tetrahedron* is a triangular pyramid with three triangular faces and a triangular base, or, in more general terms, a figure bounded by four triangular faces, each of which is an equilateral triangle and all of them equal. If we describe a sphere having its centre equidistant from each side of the tetrahedron, and make sections of the solid by planes passing respectively through each of its edges and the centre of the sphere, these planes will intersect the surface of the sphere in great circles, which will divide it into four equal and similar spherical triangles. The spherical surface will thus be *symmetrically* divided into *four* equal portions. Again, we may draw other great circles bisecting each angle of each spherical triangle. Each triangle will thus be divided into six equal right-angled triangles, and consequently the whole sphere will be *symmetrically* divided into *twenty-four* such triangles. We might in like manner proceed to subdivide the whole spherical surface symmetrically into a great number of portions, by joining points of intersections of lines previously drawn, or by drawing other great circles, having certain relations of symmetry with the primitive ones; and thus we might form a *network*, the number of lines in which would only be limited by the limitation which we should impose on ourselves in the degree to which the subdivision of the spherical surface should be carried. Such a network of great circles is termed by M. de Beaumont a *réseau triangulaire*.

* See *op. cit.* p. 863.

If we take a cube and describe a sphere having its centre in the middle point of the cube, it is manifest that each of the six faces of the solid might be projected as before into six equal quadrilateral spaces on the surface of the sphere, which would thus be divided *symmetrically* into *six* portions, and the number of spaces might be indefinitely increased by the addition of other great circles in a manner similar to that above indicated in the case of the *réseau triangulaire*. This would be our author's *réseau quadrilatéral*.

By cutting off the angles of a cube we may form a regular solid, an *octohedron*, with eight equal faces, each of which is an equilateral triangle, and each face might be projected as before, but the *reseau* which might be thus formed might be equally deduced from the cube, and is therefore included in the *réseau quadrilatéral*.

A fourth regular solid is the *dodecahedron*, which has twelve equal faces, each of which is a regular equilateral pentagon. These pentagons may be projected on the surface of a sphere into *twelve* equilateral pentagonal spaces, bounded by equal arcs of as many great circles; and the twelve spaces into which the sphere is thus divided may be again divided and subdivided by other great circles in the manner already indicated. The network thus formed is the *réseau pentagonal*, the pentagonal network of our author.

In consequence of the greater number of elementary spaces into which the spherical surface is thus divided, the greater number of sides bounding each such space, and the greater number of angles contained in it, it will be easily seen that a greater number of lines of which the symmetry is at once obvious, may be drawn in this *reseau* than in either of the preceding. It appears to have been for this reason that M. de Beaumont selected this *reseau* as the one most likely to afford the geometrical type of the network of lines formed by his *great circles of reference* of all the systems of lines of elevation existing on the face of our planet.

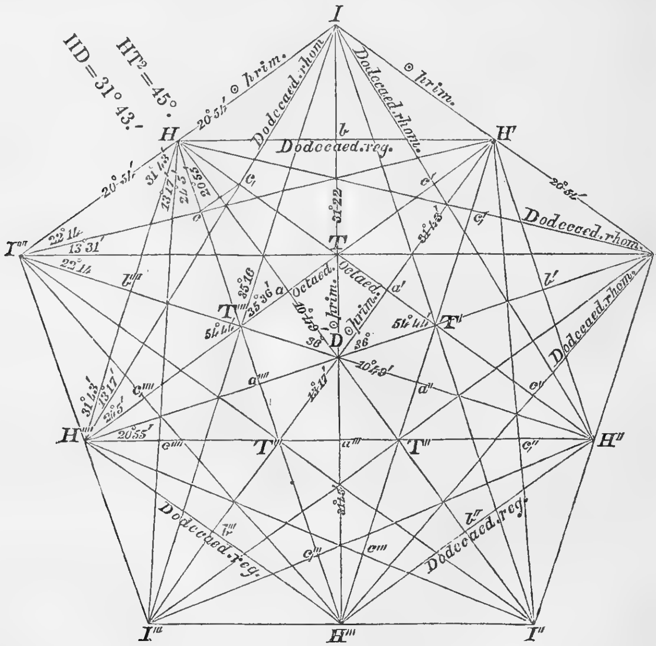
To form a conception of the positions of the twelve equilateral pentagons which occupy the whole surface of the sphere, conceive one pentagon with its middle point (that equidistant from each angular point) in a given position on the sphere. Another pentagon will have its middle point diametrically opposite to the former, and so situated that the half of a great circle drawn between the centres of these pentagons, and bisecting a *side* of one of them, shall bisect an *angle* of the other. Round each of these pentagons are five others, each of which has one common side with it; and these two series, consisting each of five pentagons, so interlace with each other, that each pentagon of one series has a side in common with one pentagon of the other series. The twelve pentagons thus occupy the surface of the whole sphere.

The symmetry of this arrangement is complete, for any one pentagon is surrounded by five others, precisely as in the manner above described.

We may also observe that a great circle drawn from the centre of any pentagon to one of its angular points, passes, when prolonged, along the common side of two adjacent pentagons. Hence it is

easily seen that if five such great circles were drawn from the central point of every pentagon, all the sides of all the pentagons would lie on these great circles, which would thus by their mutual intersections form the whole *reseau* of twelve pentagons. If all these great circles were distinct, they would be *sixty* in number; but it will be easily seen, on tracing the course of any one of these, that it passes through the centres of *four* pentagons; consequently there are only *fifteen* of these circles independent of each other, five of them meeting at the central point of each pentagon.

But a *reseau* formed by fifteen great circles only was found very insufficient to represent the complicated network of which M. de Beaumont considers his *great circles of reference* to form a part. It has, therefore, been necessary to add to the above-mentioned fifteen fundamental great circles of the pentagonal *reseau* a great number of subordinate circles, each bearing a certain relation of symmetry to the fifteen primitive circles. I have represented in the diagram now exhibited to you (see fig.), those portions of the more important of these subordinate circles, which lie within one of the twelve pentagons, all the lines being supposed projected on a plane surface.



H, H′, &c., are the middle points of the sides of the pentagon. By joining the points H H′, H′ H″, &c., we form a regular pentagon H H′ H″, &c., the sides of which are projected portions of great circles bearing symmetrical relations to the primitive great circles.

Again, by joining the points H H$''$, H$'$ H$'''$, H$''$ H$''''$, &c., we form a third pentagon, T T$'$ T$''$, &c., the sides of which are portions of another set of subordinate great circles. It will be observed also that the points a a' a'', the middle points of the sides of the pentagon T T$'$, &c., and the points b b' b'', the middle points of the sides of the pentagon H H$'$ H$''$, &c., are all symmetrically related, by their positions, to the primitive pentagon. A similar observation applies to the points c c' c'' and $c_{,}$ $c_{,}'$ $c_{,}''$, &c., the points of intersection of certain lines of symmetry as represented in the figure. There are also many points of intersection in the figure not designated by any letter, and by joining any pairs of these points respectively we might form an immense number of additional subordinate great circles, all bearing some relation of symmetry to the fifteen primitive circles and to those more immediately derived from them.

The number of subordinate circles which might thus be drawn is really unlimited. All of them properly belong to the pentagonal *reseau* in the complete acceptation of the term, but it is manifest that, taking them in the order of their formation as above indicated, their symmetrical relation to the fifteen primitive circles becomes more and more obscure. It is therefore reasonable that in any questions in which this symmetry is essentially involved, we should assign different degrees of importance, or *weight*, to these different orders of subordinate circles. Our author has estimated their respective *weights* numerically, but their absolute numerical values are obviously of no importance except so far as affording some sort of guide for that more general estimate which alone can be of any moment. He has designated the most important circles by names* derived from the immediate relations which they bear to certain of the regular solids. The relative values thus assigned to these principal circles are proportionate to the following numbers:—for

The primitive great circles	462
The Octaedrics..........................	612
The Regular Dodecaedrics	360
The Rhomboidal Dodecaedrics.............	110

The values assigned to other lines is much smaller, varying from 24 to 2. But these numbers must merely be understood as indicating that the great circles comprised in the four classes above named are those in which the characteristic symmetry of the pentagonal *reseau* is most obviously exhibited.

To complete the whole *reseau* of the sphere we must produce all the lines represented in the single pentagon of our diagram into great circles, and complete the same process for every pentagon. Many of the great circles thus drawn commencing with different pentagons will be identical, but still, even if we proceed no farther with the process than is indicated by the actual lines and points of intersection represented in the diagram, the number of great circles which are independent of each other will be immense.

* The names are attached to the respective lines in the figure.

Such, Gentlemen, is the *réseau pentagonal* of the distinguished French geologist. In my explanation of it I have omitted all the numerous and complete details given by its author, but I trust that what I have stated will enable you to understand his theory, and to judge for yourselves of the degree of importance which may attach to it. The theory of the pentagonal *reseau* asserts the approximate coincidence of each of the author's *great circles of reference* with some great circle comprised in the *reseau*; so that these *great circles of reference*, instead of being drawn, as it were, at random, on the surface of the globe, are connected by a well-defined geometrical law, and belong to a system of which the symmetry is as perfect as that of any system of great circles which can be described on the surface of a sphere. The number of great circles of the *reseau* with which *great circles of reference* of known existing systems coincide, is very small, but it is considered that other systems may yet be formed, though the whole number that ever could be formed by existing causes is probably limited by the nature of those causes and the conditions under which they operate.

The manner in which M. Elie de Beaumont first proceeded to test his theory was to calculate the angles included between the principal circles of the pentagonal *reseau**, and to compare them with the series of angles above mentioned as included between different pairs of his *great circles of reference*†. In this comparison he observed an approximate accordance sufficient, as he conceived, to afford a strong sanction to his theory. Still the inferences from these approximate coincidences of angular values were necessarily somewhat vague. The real question to be decided was—could the pentagonal *reseau* be so applied to a terrestrial globe, on which all the *great circles of reference* were delineated, so that those great circles should actually coincide with great circles forming a part of the *reseau* itself?

Our author's first mode of answering this question was a tentative graphical one. He constructed a pentagonal *reseau* with its principal great circles, of fine thread, and of such dimensions as to fit as accurately as possible on a common terrestrial globe. Thus applied it might be moved into any required position, and the first object was to find that position in which some of its great circles should, if possible, coincide, at least approximately, with the *great circles of reference*. For this purpose the central point of one of the pentagons was assumed to coincide with a point in a given latitude and longitude. This was not sufficient, however, to fix completely the position of the *reseau*, for it might still be turned about a diameter terminating in the point just mentioned. Another condition was, therefore, necessary. The one selected was, that one of the great circles of the *reseau* passing through the assumed point of given latitude and longitude should make a given angle with the meridian at that point.

When our author came to represent all his *great circles of reference* for his European systems at once, he found that a considerable

* *Op. cit.* p. 933. † *Op. cit.* p. 1128.

number of them intersected each other within a space of comparatively small extent in central Europe, and he appears to have been struck with this fact. It was, however, only the consequence of the assumption he had expressly or tacitly made in determining the positions of his *circles of reference*; for he assumes the lines of elevation of each system to be comprised in a zone which will commonly be bisected by the great circle of the system, and, since all the lines of his different European systems lie nearly in the same region, many of the corresponding *great circles of reference* must necessarily meet in the central part of that region. The proximity of these points of intersection to each other seems, however, to have suggested some point near to them for one of the pentagonal centres. It was finally chosen in lat. 50° 46′ N. and long. 8° 55′ E. of Paris, near to Remda, in Saxony. The second condition was, that the great circle DH of the *reseau* should coincide with the *great circle of reference* of the system of Tenara. It makes an angle of 13° 9′ 41″ with the meridian at the point D. It also passes through Etna. The position of the *reseau* is completely fixed by these assumed conditions, but since it may require correction when our data shall be more complete, M. de Beaumont considers the present determination as only *provisional,* though, probably, not erroneous in any material degree. He has given, in his work (Pl. v.), the pentagon which has its centre near Remda, delineated on a map of the region included in it. It comprises the whole of Europe, a small part of Asia, and a large extent of Northern Africa. The *great circles of reference* of all the European systems are also delineated on the same carefully executed map. The pentagon and map are drawn according to the *gnomonic* projection on the tangent plane to the earth's surface at the point with which D coincides.

We must now proceed to compare the positions of these *great circles of reference* with the circles of the pentagonal *reseau* in the determinate position assigned to it. And here I may remark, that if it were the question, whether the coincidence between these two groups of circles were *exact* or not, it would be easy to decide it. The difficulty arises from the fact of the coincidence sought being only *approximate,* for this involves the further question—is the coincidence sufficiently near to justify the conclusion that the general phænomena of elevation are not only due to a physical cause perfectly general as regards the whole of the earth's surface, but also such that the pentagonal *reseau* shall be the accurate geometrical type of the resulting phænomena?

In the first place, we find the *great circles of reference* for the following ten systems represented on the map as passing through the pentagonal centre D:—

System of Tenara.
System of Thüringerwald.
System of the Rhine.
System of the Ballons.
System of Finisterre.
System of the Netherlands.

System of the Côte d'Or.
System of the Western Alps.
System of Corsica and Sardinia.
System of the North of England.

I have already explained the reason why a considerable number of the *circles of reference* of the European systems, as determined by our author, must necessarily intersect each other near a common point, and I have also explained (p. xxxviii) the uncertainty of the position of the *centre of reduction* of each of these circles. That centre, it will be recollected, was *assumed* for each particular system. The ten circles of reference for the above ten systems, as previously determined, pass *near* to the point D, and they are now assumed to pass accurately *through* that point, which thus becomes a common *centre of reduction* for them all. In accordance with this assumption, each circle has been moved laterally from its position, as previously determined, through an angular space in general small, but in the system of the Rhine amounting to about 3° or 4°, and in that of the north of England to the amount, I conceive, of 7° or 8°. In these displacements there is nothing inconsistent with the previous *approximate* determinations of the positions of these great circles. The author regards them only as *provisional*, but after having assumed the ten *great circles of reference* above-mentioned to pass accurately through the pentagonal centre D, their positions, it must be remembered, are no longer *provisional*, except so far as the position of the whole *reseau* on the earth's surface is so; and, moreover, unless the position now assigned to the *reseau* be very approximately correct, the whole evidence at present adduced in favour of the theory is valueless; for that evidence rests entirely on that approximate coincidence of lines of the *reseau* with actual lines of elevation, which would be totally destroyed by any but very small displacements of the whole *reseau*.

Now, the impossibility of altering materially the positions of the *great circles of reference* of the European systems, determined as they have been from the facts afforded by a limited region, appears to me to lead to very important inferences, to which our author has not, I think, made any distinct allusion. We may allow the *directions* of these great circles within the limited region of Europe to be determined, liable to an error not exceeding 3° or 4°; but I have already explained that their assigned *positions* within that region (as depending on their *centres of reduction*) may be liable to a much greater error (p. xxxvii). Now, referring more especially to the ten *great circles of reference* above mentioned as passing through the pentagonal centre D, the evidence deducible from them in favour of our author's theory depends entirely on their passing, if not exactly, at least very approximately through that point, the amount of admissible deviation from such position being much less than the error to which, as above explained, the positions at present assigned to them are liable. For if these deviations were not very small, the *great circles of reference* could not be referred to great circles of the *reseau* passing through D as their proper representatives, and the evidence

which rests on the approximate coincidence of these two sets of great circles would be invalidated in a degree proportionate to the uncertainty with which the positions of the *great circles of reference* are determined. If the European systems should be proved to extend over much wider regions than that of Western and Middle Europe, there would no longer be the same uncertainty respecting the *centres of reduction* of these *great circles of reference,* and the evidence deduced from them would become proportionally more determinate. At present the great uncertainty respecting these centres appears to me to invalidate, in a great degree, the *existing* evidence in favour of our author's theory.

Suppose, however, that we admit the fact of ten of the European *circles of reference* passing exactly through a single point, the pentagonal centre D. Let us next examine the evidence deducible from the approximate coincidence of these great circles with the lines of the *reseau* which our author has taken for their true theoretical representatives.

I must here again refer you to the excellent map which accompanies M. de Beaumont's work, for the graphical representation of his *great circles of reference.* The table in page 1123 will enable you to appreciate accurately the deviation of each great circle of the European systems from the line of the pentagonal *reseau* which is its theoretical representative. To the twenty-one systems recognized as *European,* are added the great circles of the Volcanic axis, that of the *Ural,* and that of the *Azores.*

We observe, in this table, that in two cases out of the ten *central* systems there is a difference of nearly $2\frac{1}{2}°$ between the *great circles of reference,* as at present determined, and their respective representatives, the corresponding differences in the other cases being for the most part about 1°, except in that of Tenara, which, as I have before stated, is *assumed,* in fixing the position of the *reseau,* to coincide with one of the *primitive circles.* We must also recollect that the determinations of the angular positions of the *great circles of reference* are liable to a possible error of 3° or 4°. It is not that an error to that amount is likely to exist simultaneously in every one of these great circles, but any one of them may be so affected. Now the question is—whether, if we should draw ten lines at random through D, the angular differences between these lines and the lines of the *reseau* nearest to each of them, would be generally much greater than those above given in the table. If not, then the approximate coincidences between the *great circles of reference* and their representatives in the pentagonal *reseau,* indicated by the table, afford no evidence that those great circles constitute a system having any especial and necessary relation to the pentagonal *reseau.*

In deciding this question, we must first determine what circles of the pentagonal *reseau* must be admitted as those from which we are to measure the angular distances of the great circles which are to be compared with them. The whole number of great circles is indefinitely great; but we have seen that M. de Beaumont has assigned different degrees of importance to different *sets* of these circles, and

it here seems most reasonable to take all those sets, the importance of which, according to the author's own numerical estimate, is not less than that of any of the circles which he has selected as theoretical representatives of his *great circles of reference* of the European systems. Many of these would not pass through D, but I will first restrict myself to those which do so, and also pass through any of the sets of points H, H′ &c., I, I′ &c., T, T′ &c., *a*, *a*′ &c., *b*, *b*′ &c., *c*, *c*′ &c., and *h*, *h*′ &c., because these are points through some one of which in each set M. de Beaumont has taken a great circle to represent one of his European great circles of reference. It will be sufficient to take the portion of the sphere lying between two great circles, such as DH‴ and DI‴, since everything is symmetrical in the other similar portions of the spherical surface. The angle between two such circles is 36°, and when they are produced to their other point of intersection diametrically opposite to D, the number of points between them, such as those above specified, is about thirty. According to the rough calculations I have made, the smallest angle which a great circle from D through one of these points makes with DH‴ is nearly $4\frac{1}{2}$°, which is also the angle made with DI‴, by a great circle through D and another of these specified points. The angle between any two contiguous circles intermediate to the two just mentioned never exceeds $2\frac{1}{2}$°, and is generally considerably less. Suppose now we draw at random a great circle on the sphere, or a straight line in the diagram, through D and lying within the angle H‴ D I‴. If the line so drawn bisect the angle of $4\frac{1}{2}$° either between DH‴ and the nearest line of the pentagonal *reseau* drawn as above mentioned, or between DI‴ and the line of the *reseau* nearest to that line, it will then deviate by about $2\frac{1}{4}$° from either of the contiguous lines of the *reseau*; but if the great circle, or line, drawn at random, lie in any other position within the angle H‴ D I‴, it cannot deviate from the nearest line of the *reseau* by more than $1\frac{1}{4}$° (since the angle between two contiguous lines does not exceed $2\frac{1}{2}$°), and the deviation will generally be much less. Now, if we refer to the table above mentioned of the angles between the European *great circles of reference*, as provisionally determined, and their respective representatives in the pentagonal *reseau*, we find them quite equal to those just mentioned. Where then is the proof that the *great circles of reference* which may pass through D, may be better represented by the circles of the pentagonal *reseau* through that point, than any other set of circles drawn through it entirely at random?

I have here admitted the assumption that certain *great circles of reference* pass accurately through D; but let us now suppose them to pass *near* to D, *i. e.* within a few degrees of it, a supposition very far more probable than the former. Then we bring in many other circles of the *reseau* with which our *great circles of reference* may be compared, as M. de Beaumont has done with respect to those *circles of reference* which do not pass through D. In such case the angular space becomes still more subdivided by circles of the *reseau* exactly similar to those which our author has put into requisition. This only shows more obviously the impossibility of describing any

system of great circles on the surface of a sphere which might not be just as well represented by the pentagonal *reseau*, as that particular system formed by the *great circles of reference* of the different parallel systems of elevation, whether determined provisionally, or with all the accuracy with which, from the nature of the phænomena, we can consider it possible to determine them.

It might appear from certain incidental expressions of our author, that he regards the indefinite number of circles which may be drawn in his pentagonal *reseau* as one of the great resources of his theory; and had it been a question of *accurate* instead of *approximate* coincidence of two systems, it might perhaps have been so regarded. But in the actual case it appears to me to be this very circumstance which invalidates any proof which can possibly be given of this theory of the pentagonal *reseau*. The great uncertainty also which attaches to the present determination of the provisional *great circles of reference* appears to me to render it impossible to make a comparison between them and the great circles of the *reseau* sufficiently satisfactory to allow us to deduce from it any proof of our author's theory. The only circumstance which could at present have afforded, in my estimation, a presumption of its truth, would have been that of the approximate coincidence of the *great circles of reference* with those comparatively few circles only of the *reseau* which present to us the most obvious relations of symmetry. This, however, is far from being the case, as appears at once from the vast number of circles belonging to those classes from which the author has selected his representative circles.

M. de Beaumont has not explicitly tested his theory exactly in the manner I have now done. He has insisted on the approximate accordance of two series of angles, as I have already stated, the one series containing the angles between pairs of *great circles of reference*, and the other containing angles between certain pairs of lines of the pentagonal *reseau*. But this accordance is simply a consequence of the approximate coincidence between each *circle of reference* and its representative circle in the *reseau*, which, as I have endeavoured to show, appears to me no greater than that which might exist if we should substitute lines drawn at random for the actual *circles of reference*. The final test of the theory must, I conceive, be that which I have applied to it. The inference which I should draw from the approximate accordance of the two above-mentioned series of angles, as well as from an inspection of the map on which the *great circles of reference* are delineated, is merely that the physical cause to which lines of elevation are to be referred has so acted as to distribute those lines pretty equally with reference to different points of the compass; but, I confess that I can see no solid grounds for the induction that the author's great circles of reference have any necessary connexion with the pentagonal *reseau*.

Both these theories of M. Elie de Beaumont—that which asserts the parallelism of synchronous lines of elevation, and that which asserts the approximate coincidence of the *great circles of reference* of such parallel systems with circles of the pentagonal *reseau*—are

essentially *geometrical*, and so far are independent of the physical causes to which the phænomena may be referred. The proofs of them must necessarily rest on observation independently of any investigation of the operation of mechanical agencies, and might be complete without any physical hypothesis whatever if the theories were sufficiently *exact*. But where *approximate* proofs are all which the nature of the case will admit of, the probable truth of the theories may be increased, if it can be shown that the laws which, according to the theories, characterize the phænomena would be the necessary results of some probable mechanical agency.

Regarding the subject in this point of view, the question naturally suggests itself—whether phænomena of elevation characterized by any law of symmetry, like that for instance of the pentagonal *reseau*, would result from any assignable physical cause acting under probable conditions?

In answering this question I shall be led to make a few remarks on the physical theory adopted by M. de Beaumont, but without any intention of entering into a full discussion of it. The cause to which this theory assigns the phænomena of elevation is the contraction of the earth's mass in consequence of its refrigeration. It is assumed that the primitive state of the earth was one of entire fluidity, and that it consists at present of a solidified shell, extremely thin compared with the earth's radius, and an enormous internal fluid nucleus. The temperature of the incipient solidified shell would decrease faster than that of the interior nucleus, and would therefore tend to contract more rapidly than the nucleus. During the earliest stages therefore of solidification, the shell would be in a state of *tension* unless relieved by the formation of cracks and fissures. After a certain time, however, which M. de Beaumont considers to have long since expired, the converse would hold. The fluid nucleus would contract more rapidly than the solid crust, and would consequently tend to separate from it, and thus leave it unsupported beneath. In such case, if the crust were sufficiently thin, it might be unable to support itself, and might therefore collapse by its weight, and we may conceive ridges and furrows to be thus produced on its surface, constituting longitudinal lines of elevation. M. de Beaumont supposes these collapses to take place *suddenly* at distinct epochs, and a distinct system of synchronous parallel lines of elevation to be formed at each collapse.

There can be no doubt, I conceive, that the contraction of the earth's solid crust arising from the exceedingly slow diminution of the supporting fluid pressure beneath, would, in a great measure, be also slow and continuous. Whether this would be attended with sudden and violent collapses at long intervals of time is extremely uncertain. I believe this hypothesis to be more favourable to the theory which would assign phænomena of elevation to slow and continuous, or to small and often repeated movements, than to that which attributes them to movements of a paroxysmal character. I have no intention, however, of discussing this general question, for which we have at present but very imperfect data. Admitting, then,

that these sudden movements would result from the cause here contemplated, let us suppose the solid crust *on the point* of collapsing under its own weight. If the crust were exactly spherical, of uniform thickness, and similarly constituted throughout, the tendency to yield along *great circles* would necessarily be greater than along *small circles*, but this tendency would be no greater along one great circle than another. This exact uniformity, however, in the thickness and constitution of the crust could never accurately exist; and, consequently, neither the forces tending to crush the solid crust, nor its power of resistance would be strictly uniform, and in this irregularity we have the cause determining the particular great circles along which the yielding will take place. One of the simplest hypotheses we can here make is that of the crust being more feeble in the region immediately surrounding a particular point, than elsewhere. In such case the yielding would take place either along one great circle, or simultaneously along several great circles, passing through that point. The actual result would probably be that this yielding would not take place continuously along each great circle, but sometimes along one and sometimes along another, thus forming a *system* of detached and separate *lines of elevation* of *synchronous formation*, and characterized, not by *parallelism* to each other, but by *divergency* from a point. These diverging lines might be formed simultaneously in any direction whatever; but let us suppose them to lie between two great circles inclined to each other at a certain angle, 30° or 40° for example. We may conceive the yielding of the mass and the consequent formation of longitudinal lines of elevation to be continued far beyond the region in which I have supposed them to commence. For greater distinctness we may consider them to extend even to the point diametrically opposite that at which they have originated, and where the great circles again intersect each other. The portion of terrestrial surface lying between these two bounding great circles is termed by our author a *fuseau*,—a term adopted, I presume, as expressive of the fact, that the space to which it is applied tapers to a point at each extremity; and as far as I can understand his meaning, he appears, in his physical reasoning, to consider that each collapse of the earth's crust would arise from a simultaneous yielding along great circles of a *fuseau*, in the manner above described. But there appears to me to be an inconsistency between such a view and the theory which asserts the contemporaneity of lines of elevation which are *parallel* to each other; for the lines of elevation formed as above supposed in the *fuseau*, are *divergent* from the common point of intersection of the great circles along which they range.

It will be recollected that our author's lines of elevation in each *parallel system* are portions of *great circles*, but not of great circles which meet in the *same point*. It is this latter circumstance which characterizes the *fuseau*—that space within which, according to the above *physical* theory, a contemporaneous system of lines must lie—in contradistinction to the *zone* of uniform width—the space which must comprise a contemporaneous system according to our author's

geometrical theory. I may not, perhaps, have accurately caught his meaning, but it is evident that the distinction now pointed out cannot be omitted in any definite theory on the subject. There is only one limited position of a system in which the lines might be equally regarded as belonging to a *parallel* of a *zone*-system, or to the *divergent* system of a *fuseau*. It is that which is distant by 90° from each of the two diametrically opposite points in which the great circles of the *fuseau* meet; for in that position small portions of the diverging great circles of the *fuseau* will be *parallel* to each other, according to M. Elie de Beaumont's definition of the term. This remark applies, very approximately at least, to a limited system like any one of our author's *European systems*, which may be considered either as a part of a more extended *parallel* system comprised in a zone between two small circles, and having its own *great circle of reference*; or as a part of the *divergent* system of a *fuseau* of which the extreme points are distant 90° from the centre of Europe. On approaching nearer to either of those points by extending any one of these systems considerably beyond its European boundaries, the lines of the *fuseau* would begin to have a sensible convergence towards its extremity, and would no longer be even approximately coincident with those of our author's *parallel* system, unless the *fuseau* were much narrower than M. de Beaumont appears to contemplate.

Setting out, then, with mechanical considerations, I should be more ready to admit, as the general law of contemporaneous systems of lines of elevation, the divergency of the *fuseau* than the parallelism of the *zone*. I do not, however, insist upon the conclusiveness of any mechanical reasoning in a case where the conditions of the problem are so imperfectly known to us. M. de Beaumont's theory of parallelism is a *geometrical* and not a *mechanical* theory, and must be established or refuted by the observed geometrical characters of the phænomena, and not by abstract mechanical reasoning. At the same time, the geologist, whatever may be his faith in the law of parallelism in the extended sense in which our author insists upon it, will necessarily look for an explanation of its physical and mechanical significance. I confess that I am, myself, very imperfectly satisfied with that which M. de Beaumont has given.

After the formation of one system of lines of elevation, whether *parallel* in a *zone* or divergent in a *fuseau*, a continued shrinking of the internal nucleus would, according to this theory, gradually withdraw its support from the internal surface of the solid shell, till it should again suffer a sudden collapse, from which another system of lines of elevation would result; and in a similar manner we may conceive the successive formations of any number of such systems. If each system be regarded as a *parallel* system, its direction, as we have seen, is represented by its *great circle of reference*, i.e. the great circle parallel to the zone in which the system lies; or if each system be regarded as that of a *fuseau*, its direction might be represented by the great circle bisecting the *fuseau*. And here we may naturally ask, whether we can derive from any mechanical view of the

subject, reasons *à priori* for supposing that these different directions of the great circles of reference must be connected by any law of symmetry such as that of the pentagonal *reseau*? Now, since we shall all agree that these phænomena are referable to the continued action of physical causes, we must all agree that they must be connected by some law. Also, admitting the theory of successive collapses of the earth's crust, we may admit the symmetrical action of gravity, the principal cause of the phænomenon; but this will give us but a vague idea of the directions of the great circles along which the crust will yield in these successive collapses, and no idea whatever of the points at which such yieldings may *begin*. These directions and commencing points must generally be determined by *local* causes, of which we are, and must probably ever remain, profoundly ignorant. It is therefore that I conclude that no well-founded conviction of the probable existence of symmetrical relations between the lines in question can be deduced from accurate mechanical reasoning. The theory of the *réseau pentagonal* can, in my opinion, derive no support from that source.

You will perceive, Gentlemen, that the two parts of M. de Beaumont's theory are distinct from each other. The first part might be true to the fullest extent to which it can be asserted, while the second might have no real foundation to rest upon; and it is important that we should bear this distinction in mind. I cannot place them at all on the same level as regards the evidence adduced in their support, and the claims which they have to our attention. I should be sorry to express a harsh or hasty judgment on them. There is much in the attempt of this eminent geologist to establish his theory of the pentagonal *reseau*, which carries with it my own sympathy. I believe that every truly earnest explorer of the works of Nature must have his mind deeply imbued with the conviction that in every part of her domain the phænomena she presents to us stand in relations to each other which we express by the term *law*, and that his deepest longings will be for the discovery of such laws. It will frequently be the hope of such discovery which alone could carry him through the laborious details of his researches. No reader of M. de Beaumont's work can fail to recognize this spirit and feeling in its author; and this is entitled to our sympathy and admiration. An impartial mind can scarcely help wishing for the success of efforts of the combination of ability, ingenuity, and knowledge like those exhibited in the work before us. At the same time we are bound to recollect that the higher such efforts are, the greater danger may there be that the final judgment of the man who makes them may be unduly warped in its application to the results of his own researches. We may thus be called upon to admire the intellectual power of the philosopher, while we have no faith in the theory which he advocates. Such is my own feeling with respect to M. de Beaumont. I should fail in justice to him if I were not to testify to the great ability and knowledge displayed in his work, and I should be deficient, Gentlemen, in that open and truthful expression

of opinion which I owe to yourselves, if I did not declare my entire want of faith in the theory of the pentagonal *reseau*.

European systems of M. de Beaumont, with an Examination of some parts of the Evidence on which they are founded.—The theory of the parallelism of contemporaneous lines of elevation, rests, as I have just observed, on its own independent evidence. The amount of evidence brought forward by M. de Beaumont is very great, and is collected from such a variety of sources and depends on the geological structure of so many regions, that it is extremely difficult to ascertain the exact value of its different portions, and to separate that which constitutes independent evidence from that which involves, in a greater or less degree, the fundamental assumptions of the theory itself. All that the individual geologist can do effectively in such an inquiry is to take those regions of which the structure has been most fully investigated, and with which he is best acquainted, and to examine critically the evidence which they afford, and the conclusions which have been drawn from it. This is what I shall endeavour to do with respect to some of those parts of our own country with the geological structure of which we are best acquainted. It is to these islands that M. de Beaumont has made his most frequent and distinct appeals; and it is to the evidence hence derived that my criticisms will be almost entirely restricted. There is, as I have intimated, a large mass of evidence derived from other countries which I profess not to discuss. Such a discussion can only be profitably undertaken by those who are more intimately acquainted with the phænomena appealed to, than any one geologist can generally be beyond a comparatively limited region. In the performance of the restricted task which I thus propose to myself, it will be absolutely necessary that I should first lay before you an outline of the geological structure of those parts of our own country to which reference will be more especially made. These are the Palæozoic districts of Wales and the adjoining English counties, and of the North of England, together with the more recent geological district of the south-eastern part of this country. In this sketch my object will be to direct your attention to those phænomena only which bear directly on the questions before us. And here let me remark, that if, in discussing so comprehensive a theory as the one before us, I may appear to found objections on phænomena extending over areas of too limited extent, the obvious answer will be that they are only the areas to which M. de Beaumont has himself appealed for the establishment of his theory. And further, Gentlemen, let it not be thought that my objections are urged with any cavilling spirit of hostility to the theory of this distinguished geologist, but with a sincere desire of eliciting truth, and of elevating the noble science we cultivate into its proper place among the more rigorous inductive sciences. This theory is not brought before us in that vague and indeterminate form which might render it little more than an appeal to our imagination, but as one which, with an entire claim to the candour of criticism, shuns not its severity. It is with this feeling that I have entered upon the task which I have prescribed to myself in this address; and

if, either in my previous comments or those which may follow, I may appear to have spoken in a tone of severity, I sincerely hope that I may not be thought to have been uninfluenced by a spirit of candour, or a due feeling of respect, which no one can entertain more sincerely than myself, for the distinguished author of this theory.

I would also make another prefatory remark. This theory at present is professedly in a *provisional* state, although its author, in discussing it, may not unfrequently, and perhaps not unnaturally, have adopted a tone which might imply a forgetfulness of the fact. Consequently, M. de Beaumont ought to be allowed to modify his theory as circumstances may require without the charge of inconsistency, unless he should forfeit his right to do so by a too pertinacious adherence to his first announcements. It is not a theory to be at once either entirely adopted or utterly rejected, but is one, on the contrary, which may admit of great modifications without the sacrifice of its essential identity, or of that honour which its author may hereafter claim from it. I make these observations that my own views respecting it may not be misunderstood, and in order that the objections I may urge against the *Theory of parallelism* may be considered as against the precise form which it has assumed at the present moment, rather than against its essential principles, or some modified form which it may hereafter assume in accordance with them.

In the following sketch of the geological structure of the districts to which I have above alluded, I shall be principally indebted to the able researches of Professor Sedgwick and Sir R. I. Murchison, with the more recent and admirable investigations of the Geologists of the Ordnance Survey.

In the annexed table, M. de Beaumont's European systems, with the exception of one (that of Vercors), the geological date of which remains undetermined, are given in chronological order, as are also the sedimentary formations in the same column. The date of each system with reference to the whole series of the formations is thus presented at once to the eye. In the second column I have given the *orientation* of each system. The orientation of a *great circle of reference* is, as we have seen, different for different points of it; and, therefore, to compare the orientations of these different great circles, it is necessary to refer them all to one common point or centre of reduction. Had they all passed through one and the same point, that point might have been conveniently chosen for the purpose; but such not being the case, it was necessary to select some independent point to which all the *great circles of reference* might be reduced, by describing through it great circles respectively *parallel* to the former in the sense previously explained*. The author has made such reductions to several different points. The one here selected is Bingerloch, on the Rhine, which is centrally situated with reference to the European systems. In the third column I have given, though somewhat vaguely, most of the principal localities or countries in which each system is considered to have been recognized.

* *Supra*, page xliii.

Systems.	Orientations reduced to Bingerloch.	Regions in which the Systems exist.
I. Vendée	N. 14° 32′ W.	La Vendée, Brittany.
II. Finisterre	E. 12 21 N.	Brittany, Normandy, Sweden? Finland?
III. Longmynd	N. 31 15 E.	The Longmynd, Britanny, Normandy, Saxony, Sweden, Finland.
IV. Morbihan Lower Silurian. Upper Silurian. Tilestone.	W. 43 58 N.	Brittany. Possibly in many other places.
V. Westmoreland and Hundsrück. Old Red Sandstone (Devonian). Carboniferous Limestone.	E. 31 30 N.	Wales and adjoining English counties, Westmoreland, the Grampians, Ireland, Eifel, Nassau, the Vosges, France, Bohemia, Scandinavia, &c.
VI. Ballons Millstone Grit.	W. 16 35 N.	Many places in Great Britain and France. Extends to the Old Red Sandstone of Norway and the Devonian and Carboniferous rocks of Russia.
VII. Forez Coal-measures.	N. 11 50 W.	Several parts of France, Dudley?, Cross Fell?, Derbyshire?
VIII. N. of England Rothliegendes. Magnesian Limest.	N. 2 30 E.	Central ridge from Derbyshire northwards; Malvern Hills, &c.; Department of the Loire, &c. in France; Island of Gothland; N. of Russia.
IX. Netherlands and South Wales. Grès des Vosges and Magnesian Conglomerate of Bristol.	E. 2 0 N.	Extends discontinuously from the Elbe to Bride's Bay and southward into Brittany; S. of Ireland; Derbyshire, Netherlands, Thuringia, S. of Russia, &c.
X. Rhine Trias. { Grès bigarré. Muschelkalk. Marnes irrisées.	N. 21 4 E.	Vosges Mountains, Centre of France, Dudley and Coalbrook Dale, Ireland, Scotland, Scandinavia.
XI. Thüringerwald Lias. Jurassic Formations.	W. 36 47 N.	Thüringerwald, France.
XII. Mont Pilas and the Côte d'Or. Lower Cretaceous group (Lower Greensand, Gault, and Upper Greensand).	E. 37 55 N.	Eastern and northern parts of France, Saxony, Vosges, England (Oolitic Escarpment).
XIII. Mont Viso and Pindus White Chalk (Upper and Lower). Nummulitic Formation.	N. 21 51 W.	Mont Viso (French Alps), Centre of France, Greece.
XIV. Pyrenees Eocene of the Paris basin beneath the Grès de Fontainebleau.	W. 23 3 N.	Pyrenees, Italy, Sicily, Greece, Carpathians, S.E. of England (Weald, &c.).
XV. Corsica and Sardinia. Grès de Fontainebleau.	N. 1 11 W.	Corsica, Sardinia, upper parts of Loire and Allier, Rhone, Hungary, Syria, Red Sea.

Systems.	Orientations reduced to Bingerloch	Regions in which the Systems exist.
XVI. Isle of Wight and Tatra. Calcaire d'eau douce superiéur (Paris basin).	E. 4° 32′ N.	Isle of Wight, Tatra (a mountain S. of the Carpathians), Greece, Eastern Alps, Jura.
XVII. Erymanthus and Sancerrois. Faluns de la Touraine. Molasse (containing shells).	E. 22 18 N.	Greece, France.
XVIII. Western Alps.... Terrain de transport ancien.	N. 28 19 E.	Italy, Sicily, Northern Africa, Hungary, Poland, Crimea, Asia Minor, the Hartz, Cantal and Mont Dore, Norway, Sweden.
XIX. Principal chain of the Alps (from Le Vallais to Austria). Diluvium.	E. 15 6 N.	S.E. of England, N. of France, S.W. of France, Spain, Shores of the Mediterranean, N. of Africa, Atlas, Caucasus.
XX. Tenare, Etna, and Vesuvius.	N. 15 46 W.	Greece, Italy, Sicily.

I now proceed to a general review of the geological structure of the Palæozoic rocks of Wales and of the adjoining English counties. I begin with N. Wales.

The three leading keys to the general structure of this district are the three anticlinal lines of Caernarvonshire, Merionethshire, and the Berwyns with their synclinals. That of Caernarvonshire lies immediately on the west of the great Caernarvon range of Snowdon, Moel Hebog, &c., running in a direction N.N.E. and S.S.W. Towards the north it is interrupted by great transverse faults on the north of Snowdon, and on the south, as it approaches the coast of Cardigan Bay, it is interfered with by derangements of the strata about Tremadoc. The great Merioneth anticlinal runs from Cader Idris in a direction parallel to the former, but gradually loses its anticlinal character to the northward before it reaches the Shrewsbury and Bangor road, the beds at this extremity dipping in different northerly directions so as to form a kind of *apse*. The great mass of the Snowdonian mountains occupies the synclinal space between the Caernarvon and the more northern portion of the Merioneth anticlinal, the crest of the Caernarvon range, however, running nearer to the former than the latter of these lines. The Berwyns anticlinal is a less important feature than the two preceding ones. It ranges just to the west of the principal mass of the Berwyns, running somewhat obliquely to the crest of those mountains. On their eastern side the beds again dip towards the N.W. and thus form another synclinal trough in which the mass of the Berwyns is situated, as the Snowdonian mass is situated between the Caernarvon and Merioneth anticlinals. On the south this line soon loses its anticlinal character and terminates to the northward before it reaches the Dee, the beds forming abruptly an apse round this extremity, and passing under the Upper Silurians of Denbighshire. Between the Merioneth and Berwyn anticlinals the dip is for the most part persistent in the

general south-easterly direction, but on approaching the higher formations of Denbighshire, though interrupted in many places by great faults, they tend generally to dip beneath those formations. Further eastward from the Berwyns the structure of the district becomes extremely irregular and dislocated.

Returning to the country west of the Caernarvon anticlinal, we find N.W. and S.E. sections presenting minor undulations, but on the whole an ascending series from the shores of the Menai to the anticlinal, the strike of the beds maintaining an approximate parallelism with the direction of the anticlinal. As we proceed southward, however, the direction of the strike changes, till about Tremadoc it becomes nearly perpendicular to its normal direction. The beds here dip in a north-easterly direction into the Snowdonian synclinal trough forming the south-western extremity of that western portion of the trough directly under the crest of the Caernarvon range*. The eastern part of this trough is continued southward from the valley of Festiniog along the western flank of the Merioneth anticlinal to the Barmouth estuary.

We shall best form some distinct conception of the general structure of this district, independently of the great dislocations which traverse it, by representing to ourselves the surface of any one of its continuous strata. In the section just referred to, given by Professor Sedgwick, which runs N. by E. from near Tremadoc, the lowest beds are found at its southern extremity, dipping with the superincumbent beds in a northerly direction. These are the Lingulæ beds with the superincumbent black slates which Professor Sedgwick, in the paper just referred to, identifies for the first time with the beds of similar mineral character on the shores of the Menai Straits. This identification has been established since on better evidence by the gentlemen of the Ordnance Survey. We may therefore conclude that the position of the Lingulæ beds in the series of formations is not remote from the surface on the shores of the Menai. Following then the surface of these beds in imagination from thence eastward, we shall have it near the level of the sea along the Menai, and forming ridges and troughs till it rises up to the Caernarvon anticlinal to which the ridges and troughs are parallel. To the east of that line the surface will sink rapidly to form the Snowdonian trough, at the south-western end of which it again rises to above the sea-level. If a section could be continued to the S.W. from Tremadoc under the sea into Cardigan Bay, we should probably find beds lower in the series than these Lingulæ beds, so that the surface of these latter must be there continued as an imaginary surface rising, perhaps, to a considerable height above the sea-level, and forming possibly an anticlinal line along the prolonged axis of the Snowdonian trough. On the E. of this line they would, at all events, dip towards the S.E. under the coast to rise again, as they are observed to do along the western flank of the Merioneth range, thus forming the synclinal trough above mentioned as the southern continuation of the wider trough between the Caernarvon and the

* Quart. Journ. Geol. Soc. vol. iii. p. 139. Section, by Prof. Sedgwick.

northern part of the Merioneth anticlinal. The Lingulæ beds are again found on the eastern flank of this anticlinal, over which, therefore, their surface must be conceived to pass as an imaginary surface rising possibly to a great elevation above the lower beds which rise to the existing terrestrial surface along the Merioneth anticlinal, and which appear to be some of the lowest beds recognized in the whole series. Our imaginary surface will descend to meet again the existing terrestrial surface on the eastern flank of the anticlinal along a line parallel to the anticlinal axis; after which, dipping to the S.E., it meets an enormous fault running along the valley between Dolgelly and Bala, the downcast of which on the N.W. side, near Arran Mowddy, is estimated at not less than 12,000 feet. By this fault the Lingulæ beds are again brought to the surface, beneath which they again dip very rapidly in the same south-easterly direction as before, to descend beneath the Berwyns to an enormous depth. It is however in the north-eastern corner of this district, in Denbighshire, that our stratum, or its equivalent, must descend to its lowest level. It must there form a depression in which is accumulated the whole series, not only of the Lower Silurian beds above the one in question, but also of the Upper Silurians found in that locality. To the S.E. of Cader Idris the Lingulæ beds pass under the Lower Silurians of S. Wales.

In contemplating the external features of a mountainous tract, the eye never fails to exaggerate greatly the real relations which the vertical elevations bear to the horizontal distances, but it will frequently fail to give us an adequate conception of the *geological* elevations and depressions of the same tract, as they would be presented by the surface of a continuous stratum, if it were cleared of its superincumbent mass where covered up, and restored where it has been destroyed by denuding agencies. Professor Sedgwick estimates the thickness* from the bottom of the Lingulæ beds to the top of the Bala group at something more than 16,000 feet. Mr. Jukes estimates the thickness at 24,000 feet†, but this estimate may perhaps apply more accurately to localities which present a full development of the lower or Trappean group of this mass. Now about the valley of the Dee, and north of the Berwyns, the Bala beds dip directly under the Upper Silurians of Denbighshire, at a level not very much above that of the sea; and consequently the depth of the equivalent of the Lingulæ bed is probably there at the depth of at least 16,000 feet, taking the lower of the above estimates. Again, if we conceive the Lingulæ beds continued across the Merioneth anticlinal, they would probably rise to the height of 4000 feet above the level of the sea. Hence between the summit of this *geological range* and the bottom of the *geological depression* of Denbighshire, the difference of level may be estimated at about 20,000 feet, or nearly four miles.

We have already seen that the basset edges of the Lingulæ bed, or its equivalent, near Tremadoc and on the shores of the Menai, are

* Quart. Journ. Geol. Soc. vol. viii. p. 147.
† Quart. Journ. Geol. Soc. vol. iv. p. 300.

not very far from the sea-level, and such appears also to be the case east of Bangor slate quarries. Consequently the geological level of this part of the district is probably at least some 15,000 or 16,000 feet higher than that of Denbighshire. The depth of the synclinal trough formed by the same beds between the Caernarvon and Merioneth anticlinals must probably be much smaller than the above. On the south-eastern side of the Merioneth anticlinal, the surface of our imaginary bed would form a deep valley, bounded on the S.E. by the escarpment of the enormous fault just mentioned, on the south-eastern side of which it would form a still deeper parallel valley. Hence in N. Wales there are three great parallel geological troughs, the Snowdonian one extending from Tremadoc to the north of Snowdon, and the other two deeper ones terminating on the N.E. in the deep depression of Denbighshire. Towards the S.W. the more eastern of these troughs is continued into the Silurian basin of the southern part of the Principality, while the intermediate one must terminate about Cader Idris.

I have now to speak of the *faults* of this district. Wherever the continuity and regularity of the longitudinal troughs are preserved, we find a corresponding regularity in the longitudinal faults running parallel to them. This regularity is particularly observable on both sides of the Menai Straits. Further to the south-east, the most important fault of this kind is the enormous one already mentioned as running along the Dolgelly and Bala valley. From the former of those places, to near the northern extremity of Bala Lake, it steadily preserves its north-easterly course; but, at the latter point, it is gradually deflected towards the east, so as to preserve an approximate coincidence to the strike of the beds, which, in the valley of the Dee, instead of being N.E. and S.W. becomes nearly E. and W., the beds dipping under the Upper Silurians of Denbighshire. This fault is finally hidden under the New Red Sandstone at its north-eastern extremity, after dislocating the Millstone Grit and the Coal as well as the lower formations, showing the date of this portion, at least, of the fault to be posterior to the Coal*. Another leading longitudinal fault proceeds from the estuary of Traeth Maur, on the west of the Merioneth anticlinal. It runs N.E. till it approaches the Denbighshire depression, when it is deflected towards the north so as to follow the south-western and western boundary of the Denbighshire depression, which it embraces on that side as the former-mentioned fault embraces it on the south and south-east. No considerable fault has been observed to pass from the S.W. directly into that basin, which is surrounded by faults running along its curvilinear boundary on the south and west where the beds dip towards the centre of the basin, as well as on the east where they dip towards the east. These faults, since they coincide approximately with the *strike* of the beds, are properly *longitudinal* faults. It is at these places, where the strike of the beds changes suddenly from its normal north-easterly direction, that we always find, as we might expect, the most numerous dislocations. Very striking

* I infer this from the Geological Map of the Ordnance Survey.

examples occur near Tremadoc, at the north-eastern termination of the Merioneth anticlinal elevation, and near the northern extremity of Bala Lake.

I do not wish on this occasion to intrude upon you my own theoretical views, but I may be allowed, perhaps, to observe, that the phænomena now described are strictly in accordance with the theory of elevation which I have so frequently advocated, and with the hypothesis that the disturbances and dislocations of the strata above described are of contemporaneous origin. The parallelism of the southern portions of the two great longitudinal faults which I have described as embracing the Denbighshire basin on opposite sides, and their continuity, afford strong proof that they are of the same age throughout their whole lengths; and that their divergency of 50° or 60° from each other in their more northern portions is due to the particular conditions under which the elevating forces acted, and not to the circumstance of these latter portions being referable to widely different geological epochs, while their southern portions are to be referred to the same epoch.

The structure of the district on the north, the east, and the south of the Berwyns is very complicated. On the north the beds dip, with numerous dislocations and irregular disturbances, under the Upper Silurians of Denbighshire, as already stated. On the south they dip in a similar manner under the Upper Silurians contained in a geological depression similar to that of Denbighshire, but smaller in extent, and extending in an east and west direction from Welchpool to Mallwyd, a place nearly on the same meridian as the southern end of Bala Lake. Sections parallel to the Berwyns, N.E. and S.W., and to the east of those mountains, exhibit an anticlinal line, the direction of which is somewhat N. of W. and S. of E., and therefore nearly perpendicular to the Berwyns anticlinal. The northern and southern extremities of such sections exhibit what is considered as Caradoc Sandstone, and has been coloured as such on the Ordnance Map. The beds more immediately on each side of the nearly east and west anticlinal are those which rise from beneath the north and south synclinal trough containing the mass of the Berwyns, and must therefore consist of beds the equivalents of others existing to the west of the Berwyns anticlinal.

If we again recur to the surface of our hypothetical stratum, we now observe that the great geological valley on the eastern side of the great fault of Dolgelly and Bala not only descends into the deep depression of Denbighshire on the north, but also into a similar one on the south between the Severn at Welchpool and the Dyffi at Mallwyd. To the east of Bala Lake, in the central portion of the space intermediate to these two great geological depressions, our hypothetical stratum rises again under the Berwyns to form the east and west ridge running from that range to the borders of Shropshire, where these older beds become hidden beneath superincumbent and unconformable strata. On the S.W. both the great geological valleys east of the Merioneth anticlinal are continued into

the southern part of the Principality, to the structure of which also I shall, in the sequel, have to direct your attention.

This abnormal form of the geological surface, defined by our ideal stratum, is accompanied, as might be expected, by irregular faults in this part of the district. Towards the eastern extremity, however, of this local E. and W. anticlinal, a distinct tendency to E. and W. faults is easily traceable.

If we produce the line of the Merioneth anticlinal to the S.W., it just meets the south-western extremity of South Wales near to St. David's, where rocks belonging unequivocally to the older non-fossiliferous rocks of the Cambrian series again show themselves at the surface. It seems impossible to regard this phænomenon otherwise than as indicating the probable continuation of the above anticlinal from Barmouth to St. David's along the bed of Cardigan Bay. Again, along the margin of the Old Red Sandstone from Builth to Llandovery and thence along the valley of the Towy, we have a strongly-marked anticlinal ridge, the direction of which between Builth and Llandeilo is exactly parallel to the Merioneth line, but becomes more westerly in proceeding by Carmarthen. At the Longmynd we again find non-fossiliferous beds, which Professor Ramsay* considers as identical, in all probability, with the old purple, green, and grey sandstones of Barmouth; and superincumbent upon them, to the north of Bishopscastle, we have other beds which he regards as the representatives on a small scale of the igneous rocks and slates of Merionethshire. Also immediately to the north of Builth, beds similar to these latter show themselves, and the line joining these localities, near Builth and Bishopscastle respectively, coincides approximately with the strike of these beds at those places†, is nearly parallel to the Merioneth line, and nearly coincident in direction with the anticlinal just mentioned between Builth and Llandeilo. Hence the whole line from Llandeilo to the Longmynd, very nearly parallel to the Merioneth line, may be regarded as the south-eastern boundary of the great general synclinal trough which proceeds southwards from the borders of Denbighshire to Pembrokeshire, as the Merioneth line prolonged to St. David's may be considered its parallel and opposite boundary. South-west of Llandeilo, the boundary trends more and more from its south-westerly course till, on the southern boundary of the trough, it assumes a direction almost exactly east and west.

Sections running from Aberystwith, or points south of that place on the shore of Cardigan Bay, in a S.E. direction, and meeting the Old Red Sandstone S.W. of Builth, exhibit many undulations, the axes of which run nearly N.E. and S.W., the most important, perhaps, being that which follows, as an anticlinal ridge, the course of the River Teifi, as the similar ridge already described on the

* Quart. Journ. Geol. Soc. vol. iv. p. 295.

† This must be understood as stated in very general terms. The strike of the Longmynd beds deviates from the direction spoken of in the text, by a considerable number of degrees.

skirts of the Old Red Sandstone follows the course of the Towy. In this undulating character the southern part of the general trough differs from the more northern portion, where the beds between the Merioneth and the Berwyns anticlinal dip generally with great regularity to the S.E., but are broken by enormous longitudinal faults. Consistently with these undulations, it has been shown that beds which appear at the surface on the shores of Cardigan Bay, near Aberystwith, are also found near the south-eastern boundary of the Silurian district*. These beds belong to the Bala series. The beds S.E. of Cader Idris, belonging to the lower fossiliferous beds of Merionethshire, were long since observed by Professor Sedgwick to dip beneath them, but their exact place in the series of deposits had not then been determined.

The depth of the trough in S. Wales would be nearly uniform between the limits as above defined on the N.E. and S.W., with the exception of the variations arising from the intermediate longitudinal ridges and furrows. Its general depth may not, perhaps, differ much from the deepest part of the most eastern trough of N. Wales immediately west of the Berwyns.

If we now pass south-eastwards across the anticlinal line running from St. Bride's Bay to Builth, we find the Silurian beds descending with a very rapid dip beneath the Old Red Sandstone, the Mountain Limestone, and the Coal-measures of South Wales. The Old Red Sandstone along this boundary dips very persistently to the S.E.†, but deviates more to the south as it approaches the basset edge of the Mountain Limestone, where that edge assumes an east and west direction. Proceeding further to the N.E. along the line already indicated from Builth to the Longmynd, we also observe the dip on the S.E. of that line, though subject to many local variations, generally to the S.E. If then we examine the position of our ideal stratum in the region now under consideration, we shall find it regularly descending under the Old Red Sandstone, but more rapidly as it approaches the Coal district. Supposing the Silurians to be continued with undiminished thickness under the last-mentioned formation, our ideal stratum will descend to a level many thousand feet lower than on the north-western side of the anticlinal along the boundary of the Old Red Sandstone. Professor Ramsay estimates‡ the thickness of the Old Red Sandstone to vary from 4000 to 7000 feet, and that of the Carboniferous Limestone from 100 to 2000 feet, and that of the Coal-measures from 8000 to 12,000 feet; so that the upper part of the Silurian series, in the lowest part of the Coal-field, is probably at a depth not less than 15,000 feet. To this must be added the whole thickness of the Upper and Lower Silurians in the same locality. At this southern end, therefore, of the Principality, we have an enormous geological depression, similar to that in Den-

* "Sketch of the Structure of North and South Wales," by Professor Ramsay, Quart. Journ. Geol. Soc. vol. iv. p. 297, and Sections of the Geological Survey.

† Geological Map of the Ordnance Survey; and the Map of Sir R. I. Murchison's *Silurian System*.

‡ Memoirs of the Geological Survey, vol. i. p. 316.

bighshire, but probably still deeper, and both opening out to the eastward at much greater depths than in the space between them, supposing always the whole surface defined by an ideal contemporaneous stratum pervading the whole region. The general synclinal trough of the Principality descends directly into the northern depression of Denbighshire, but is separated from that of the South Wales coal-basin by a strongly marked anticlinal ridge.

In the portion of S. Wales between the great anticlinal of the Towy and the coast of Cardigan Bay, faults equal either in magnitude or number to those of N. Wales have not been observed. The folds of the strata are more unbroken, and form regular anticlinal and synclinal lines, which follow a law exactly similar to the anticlinal of the Towy. In proceeding towards Pembrokeshire, they change gradually and continuously from their south-westerly to the westerly direction which they attain near their southern extremities. In the great Coal-basin of S. Wales, the faults which have been detected are principally perpendicular to the strike, and are therefore *transverse* faults. They are numerous, and principally along the borders of the basin. Analogy, however, would lead us to infer that characteristic longitudinal faults must probably exist also in the centre of the basin, where the coal-beds on account of their greater depth are less worked, and consequently the geological structure less perfectly known than near the boundaries of the field.

In the North of England the geological structure of all the Cambrian and Silurian rocks is very regular. They present one uniform N.E. and S.W. strike. The Old Red Sandstone does not exist in continuous beds, but only in patches of rough conglomerate. The Carboniferous Limestone rests unconformably on the inferior beds, and has been so elevated that any continuous stratum forms a surface which we may follow in imagination as we have already done in Wales and the neighbouring district. From Derbyshire to Northumberland such a surface descends towards the east from a central ridge, which is sometimes an anticlinal line from which our supposed surface dips rapidly to the west, or along which it is discontinuous on account of enormous faults bounding the limestone districts on the west. North of Stainmoor the fault assumes the direction of about N.N.W., those in the southerly part of the district being nearly N. and S. The region east of the central ridge is also traversed by numerous transverse dislocations, the general direction of which is east and west. On the west of the central ridge, our supposed surface would form a projecting eminence in the Lakes district of Westmoreland and Cumberland, terminated by a complete *apse* at its western extremity, and having a general east and west direction, and therefore nearly at right angles to the central ridge above mentioned. To the north of the Lakes and the west of Cross Fell, and to the south of the Lakes and west of the central ridge of Yorkshire, the same limestone-bed descends beneath the existing terrestrial surface.

The whole of this region from Northumberland to Derbyshire, and on the east of the great central ridge of the north of England, presents that character of continuity in its general structure which na-

turally associates itself with the idea of the contemporaneous origin of its distinctive phænomena. The longitudinal faults run northerly and southerly, and the transverse ones easterly and westerly, and great numbers of them follow this direction with great accuracy. The Lakes district presents an exception to this rule. It forms an anticlinal elevation running nearly E. and W. and terminating on the west in a regular apse. If we assume, as seems highly probable, that the Lake valleys originated in great dislocations, the faults of this district must be considered as diverging, round the apse, with great regularity from a central point. I have elsewhere shown that such a disposition is perfectly accordant with the contemporaneous origin of these faults, of which I regard it, in fact, as the strongest indication.

I now proceed to examine the discontinuities of stratification by which we must determine the proximate periods of those movements which have so disturbed the strata of these regions of Wales and the north of England.

It does not appear that any distinct geological horizon of discontinuity in Wales has been detected, notwithstanding the accurate researches of the Geological Survey, anterior to the period of the Caradoc Sandstone. I am not aware even of partial discontinuities before that epoch, which appears the more singular on account of the enormous mass of contemporaneous igneous products among the beds which constitute the Barmouth series. Nor, with the exception of particular localities, does the discordance between the beds of the Caradoc and those on which they are superincumbent appear to be considerable. It is manifested over the widest area in that part of N. Wales where the upper beds of the Caradoc seem to gradually overlap the lower formations in wrapping round the northern end of the Berwyns, and in their north-western extension from that locality. The greatest amount of discordance is exhibited about the Longmynd, where the Caradoc beds are superimposed with great unconformity on the edges of the nearly vertical beds of the much older rocks of that district.

In the trap region of Carneddau, to the N.E. of Builth, one transverse section of the Survey exhibits the beds of the Wenlock Shale in conformity with those of the upper Llandeilo Flags, the whole being disturbed together by the outbreak of trap; and another section shows beds of the Wenlock Shale in positions almost perpendicular to Llandeilo beds, much lower in the series. In these sections the Caradoc beds are wanting. When we pass out of this limited Trappean locality towards the S.W., no appearance of any corresponding discontinuity in the stratification has been observed. There is, on the contrary, a remarkable conformity from the Lower Silurians to the Coal-measures inclusive, the only indication of non-conformity being an extension, in some cases, of a superincumbent beyond a subjacent formation, but without a greater difference in the inclination of the beds of the respective formations than would result from that gradual depression which must have accompanied the long-

continued deposition of sedimentary masses of such enormous thickness as those we are considering.

If we turn now to the district lying on the east and south-east of the line of Trappean eruption from Builth to the Longmynd, we find the same conformity between the Upper Silurians and the Old Red Sandstone, wherever the latter exists, and in the eastern part of the S. Wales coal-district, we have the same conformity, as in the western part, between superincumbent formations up to the Coal-measures. Further to the north, in the Shropshire coal-fields, the Old Red Sandstone does not exist, and the Carboniferous Limestone, where it exists, reposes immediately on the Silurians, on which also the Coal reposes in the absence of the Carboniferous Limestone; but in these cases the stratification of the Silurians and superincumbent limestone or coal-measures is always, or very generally, decidedly discordant. On these points excellent details and sections are given by Sir Roderick Murchison in his *Silurian System*. I am not acquainted with the details of superposition in Denbighshire.

In the North of England the break between the Upper Silurians and the superincumbent beds is very decided. There the beds of Carboniferous Limestone are observed in many places to lie, with a comparatively small inclination to the horizon, on the highly inclined Silurian beds. No discontinuity, however, has been there observed corresponding to that belonging to the period of the Caradoc Sandstone in Wales.

The next great discontinuity which exists in the stratification of the Palæozoic rocks both in Wales and the adjoining districts, and in the North of England, is that between the Coal-measures, speaking generally, and the superincumbent beds. In the West of England, Sir Roderick Murchison has ascertained that, in several localities, the Coal-measures graduate into the lowest Permian beds. In the North of England, on the contrary, Professor Sedgwick has observed the lowest Permian beds of that region resting unconformably on the Coal strata; and the same is true with respect to the Dolomitic Conglomerate of the neighbourhood of Bristol and the south-eastern part of the coal-basin of South Wales. There are also discontinuities between different portions of the Permian and Triassic groups which will be more particularly discussed as we proceed. They are important with respect to the history of the movements, the effects of which are so striking in the Coal-measures.

In tracing the history of those revolutions of the globe in which the above discontinuities of stratification have arisen, it appears to me necessary to bear distinctly in mind three different kinds of terrestrial movements: First, those great movements which, extending over comparatively wide areas, have dislocated the strata, and left them inclined in a greater or less degree to their original horizontal positions, thus producing anticlinal lines, faults, and other phænomena of elevation throughout the whole district in which the movements have taken place. Such movements may or may have not been accompanied with outbreaks of igneous matter, such outbreaks, when

they do take place, being restricted to limited portions of the elevated area. Secondly, movements extending over comparatively small areas, frequently producing violent local disruptions, and always attended by outpourings of igneous products at numerous points over the whole elevated area. I do not mean that these two kinds of movements are necessarily referable to causes of different kinds, but possibly to causes of the same kind acting under different conditions, and therefore producing phænomena with distinctive characters which it is expedient to bear in mind in the discussion of these phænomena. Thirdly, those movements of depression which must have taken place very slowly and continuously, or by small and frequently repeated steps, during long periods of the deposition of sedimentary matter. That such movements have taken place follows as a necessary consequence of the law of distribution of organic beings, which asserts that each class of marine animals can only flourish within comparatively small limits of depth. What an enormous depression, for instance, must have taken place in the region of S. Wales between the period of the earliest fossiliferous beds and that of the coal-measures, an interval of time during which no great sudden movements can have taken place in that region, as proved by the continuity in the stratification throughout that immense mass of sedimentary matter. There may also have been, in like manner, slow and continuous elevations, but of such movements we have not the same demonstrative proof, as of the continuous movements of depression.

It would seem impossible that the intrusion of the enormous mass of contemporaneous igneous matter contained in the Barmouth series should not have been accompanied with some disturbance of the stratified deposits, though, as I have already observed, it was not sufficient to produce any discoverable discontinuity in the stratification. These eruptions of volcanic matter are doubtless to be referred not to one particular epoch, but to successive epochs during a long lapse of time. Also, anterior to any great and more sudden movement, there must have been that enormous continuous descending movement which, during the deposition of the whole Silurian series, must have depressed the lower beds from the depth of a few hundred feet below the surface of the sea to that of several thousands.

The first movement to which a marked discontinuity can be traced was that of the Caradoc period. It does not appear, however, to have affected any large portion of S. Wales, and in the neighbourhood of the Berwyns it did not assume the character of a great elevatory movement belonging to the first class of those above enumerated. It seems rather to have belonged to the third class in which a comparatively small unequable depression produced a discontinuity of stratification, but one of only small amount. If we refer a considerable part of the elevation of the Longmynd to this period, together with the volcanic eruptions and dislocations from thence to Builth, the movement must there have belonged to the second class of the above cases, and have extended, as thus characterized, over a small area.

The determination of the exact epoch of this movement is a point

of great interest, because it appears to be associated with that great change in organic life which constitutes the transition from the Lower Silurians of Sir R. Murchison or the Cambrians of Prof. Sedgwick, to the Upper Silurians of the former geologist. If we draw the line of demarcation between these two great divisions of the Palæozoic rocks immediately above those beds which have been generally regarded as the upper of the Caradoc beds, we have a considerable number of organic forms common to the Upper and Lower Silurians. This community of character in the organic contents of these rocks has been particularly noticed by Mr. Phillips in the Malvern district, and the higher of the beds considered as Caradoc in N. Wales have been observed to contain many Wenlock species; but we owe to the accurate and acute observation of Prof. M'Coy the suggestion that the proper line of demarcation between the Upper and Lower Silurian groups ought probably to be drawn between the beds hitherto considered as Upper Caradoc, but containing many Wenlock species, and the subjacent beds which are distinguished by Lower Silurian fossils and constitute the true typical Caradoc. The Caradoc beds of May Hill, those which wrap round the Berwyns on the north and north-west, and those which lie on the boundary of the Longmynd, belong to the first of these groups. The subject, as you will recollect, was recently brought before us by Prof. Sedgwick, and the testimony of Prof. M'Coy affords good reason to believe that the *per-centage* of species common to the Upper and Lower Silurians will be considerably reduced by adopting this new plane of separation between them. Should this be the case, it will be a valuable step in our geological classification, bringing the phænomena in our own country into more perfect coordination with the corresponding phænomena of N. America and Bohemia, where the number of species common to the two great divisions of the Palæozoic rocks of which we are speaking, is much less than it has hitherto been considered to be in these islands. Mr. Hall remarks*, "Commencing with the lowest rocks known to contain fossils, we find the first important change in the typical forms to occur at the termination of the Hudson-river group; which is marked by a coarse sandstone or conglomerate (the Oneida conglomerate or Shawangunk grit), beyond which scarcely a single species has prolonged its existence. This point must be considered as representing that horizon which, in Great Britain, is the termination of the Lower Silurian deposits." M. Barrande divides the Silurian rocks of Bohemia into two great divisions, corresponding to the Upper and Lower Silurians of Sir R. Murchison. Their separation does not appear to be marked by non-conformity in the stratification, but by a great overflow of igneous matter. This Trappean mass alternates with argillaceous schistose beds containing about twenty species of Graptolites, identical with those found in beds of a similar character at a considerably greater depth in the series. The same beds contain also about

* Palæontology of New York, vol. i. Introduction, p. xvi.

twenty or thirty species of other kinds of animals likewise identical with species in the lower and similar beds just mentioned. Now M. Barrande places this trappean mass with its included schistose beds at the bottom of his *upper division*, and thus there are forty or fifty species common to his two divisions*. It was justly remarked, however, by Prof. M'Coy, that there seems to be no reason why this mass should not be regarded as the top of the *lower division*, in which case all the Graptolites would be contained in that division, and the number of species of organic remains common to that and the upper division would be reduced to twenty or thirty. The whole number of species discovered by M. Barrande two or three years ago was upwards of eleven hundred. These numbers would give between two and three *per cent.* as common to the upper and lower Palæozoic divisions. Prof. M'Coy has made a similar estimate from the fossils contained in the Cambridge Museum, and finds about fourteen or fifteen *per cent.* common to the Upper and Lower Silurians, supposing the May Hill and similar beds to be included in the Caradoc; but if these latter beds be placed, as Prof. Sedgwick and himself have maintained they ought to be, in the Upper Silurians, he believes that this *per-centage* might be considerably diminished. It is very desirable that the palæontologists of the Geological Survey should give us an accurate estimate of the same kind, for it is only by a strict numerical estimate, and not by general impressions, that we can really decide how far our own country presents an anomaly when compared with the perfectly developed but restricted region of Bohemia on the one hand, and the wide field of North America on the other.

It will be a strong argument in favour of the new plane of separation between the two great divisions of the Silurian rocks, should the discontinuity of stratification in Wales and the adjoining counties which belongs to this period be found to coincide with that plane. At present the evidence is in favour of this conclusion, for in every case, I believe, in which the discordance has been observed, it is between the *upper beds* of the Caradoc and lower beds in the series. It is to the corresponding epoch that I am at present disposed to refer the movement with which we are here concerned. In the North of England, as I have above remarked, there is no evidence of a corresponding movement.

It appears singular that a geological epoch at which so extraordinary a change took place in organic life over a large part of the surface of the earth, should be one to which M. de Beaumont has not been able to refer a single European line of elevation. After this period, the bottom of the widely extended Silurian sea must have remained, with the exception of a few particular localities, comparatively horizontal, and ready to receive the deposits of the Upper Silurian beds through the whole area of the West and North of England now under consideration.

* Bulletin de la Société Géologique de France, January 1851, p. 153.

The next movement is that of which the North of England affords such distinct evidence. It took place either immediately after the conclusion of the Silurian period, or, as M. de Beaumont has concluded, immediately after the deposition of the Tilestone, and previous to that of the Old Red Sandstone. Its effect on the position of the Silurian beds is shown by the great want of conformity between them and those of the Carboniferous Limestone deposited on their upturned edges. It extended towards the South-west as proved by a similar unconformity in the coal districts of Shropshire*. In the whole of this area, from the North of England to the Severn, the Old Red Sandstone is wanting, except in a few localities about the Lakes district. It commences on the south and west of the Severn and passes under the coal-field of S. Wales, resting *conformably*, as already stated, on the subjacent Silurians, thus showing that the movement of which we are now speaking did not extend into this region. It would seem probable that it so elevated the bottom of the sea throughout the area over which it extended as to prevent in a great measure that deposition of the Old Red Sandstone which succeeded this epoch, in that part of the sea to which the movement did not extend. The elevation of the sea-bottom might probably extend into N. Wales.

The masses which formed this elevated sea-bottom (or possibly, in some parts, dry land) must have been subjected to denudation for an enormous period, during which the deposition of the Old Red Sandstone might be taking place further to the south. The smaller depth of the sea in the Shropshire region and in that of N. Wales in the same latitude, would also seem to be indicated by the thin deposits of Carboniferous Limestone, or its entire absence.

This movement between the Upper Silurians and Old Red Sandstone is also recognized in the S.E. of Ireland. In the counties of Wicklow, Wexford, and Waterford, it gave a general strike of about N.N.E. and S.S.W. to the beds, instead of the N.E. and S.W. direction of the corresponding beds in England†. In Scotland the discontinuity between the Old Red Sandstone and inferior beds is distinctly recognized, but in the Grampians the strike of the former is about N.E. by E., differing from that in Ireland by about 30°. I have already stated that the movement produced no sensible effect in S. Wales. The slight discontinuity sometimes observable in Pembrokeshire and elsewhere‡, in an apparent overlapping of the Old Red Sandstone and Carboniferous Limestone over the lower formations, must be attributed to that gradual depression which, it must not be forgotten, must have been almost incessantly going on during the periods to which we are referring.

It appears probable, as Sir Roderick Murchison has pointed out, that frequent outbursts of volcanic matter took place, and often along pre-existing lines of vent, during the interval between the Silurian period and that of the Coal-measures; but the elevatory effects of

* Vide *supra*, page lxx.

† Sir H. De la Beche, Memoirs of the Geological Survey, vol. i. p. 222.

‡ Memoirs of the Geological Survey, vol. ii. part i. p. 197.

these volcanic efforts were only local, belonging to the third class of the movements enumerated above. Independently of such minor movements, the next of which Wales and the adjoining English counties afford distinct evidence were the great and general movements which broke up the Coal-measures, and doubtlessly extended far beyond the present boundaries of the coal-districts in every part of the island.

These movements took place during the Permian and Triassic periods, but there is still great uncertainty as to their number and respective epochs. In the North of England, the movement which first broke up the Durham coal-field must have been anterior to the lowest beds of the Permian group, for those beds have been observed by Prof. Sedgwick reposing unconformably on the Coal-measures. In Nottinghamshire and Derbyshire, the Magnesian Limestone is considered to rest unconformably on the Coal. Again, on the southern boundary of this Coal-field the coal-beds abut directly against beds of the Triassic series, along a great *transverse* fault, and the Magnesian Limestone on the east of the field dips eastward like the Coal-measures themselves. These facts indicate at least two great movements, one anterior to the Permian period, as in Durham, the other during the Triassic period, and probably after the deposition of a large portion of that formation, but making the beds affected by it dip in the same easterly direction, and therefore with the same N. and S. strike as that resulting from the former movement. Both movements according to this view have the *same characteristic direction.*

The district which lies on the eastern side of England and extends from Northumberland to Derbyshire, presents to us in its phænomena of elevation a great character of continuity. It is bounded on the north by a great fault, called the *Tynedale fault,* running E. and W.; on the south by similar E. and W. faults, the principal of which is that above mentioned as separating the Coal-measures from the Trias; and on the west by the great *Penine fault,* running from the western extremity of the Tynedale fault near Brampton, on the north, to Kirby Lonsdale, where it joins the Craven fault running E. and W.; and further south we have the great disturbances of Ribblesdale and Derbyshire. Without going into the details of structure, I will quote Professor Phillips's conclusions respecting the movements in this district, as given in his 'Geology of Yorkshire' (vol. ii. p. 122). I can state also that he has had no reason since the publication of his work to alter the views then expressed.

"Upon the whole then," he says, "from general considerations we find it *probabl.* that the great north and south system of faults from Brampton to Derbyshire, was occasioned before the production of any beds connected with the New Red Sandstone: particular examinations prove the northernmost (Tynedale) branch and the southernmost (border of Derbyshire Coal-field) branch from this system, both running eastward, to have been disturbed *during* the New Red Sandstone period: there is *no sufficient proof* on the line of the Cross Fell or Craven faults of their exact date: yet the general unconformity of the whole Red Sandstone system, the generally hori-

zontal or slightly inclined surfaces of the magnesian conglomerate at Kirby Stephen and Bela bridge, as well as at Westhouses near Ingleton, lead to the conclusion that these faults were anterior to the magnesian rocks. The only objection to this conclusion is derived from a limited dislocation of the conglomerate near Brough, where however it is not in conformity of disturbance with the carboniferous limestone. Upon the whole then I venture to adopt the conclusion, that the Penine and Craven faults, as well as the Ribblesdale and Derbyshire disturbances, preceded the Magnesian Limestone epoch, but the Tynedale fault and some other considerable dislocations are of somewhat later date. It is however impossible to close the discussion without expressing the surprise I feel, that such a complicated problem as that of the age of a great system of convulsions should ever be thought easy of solution."

I would remark on the above extract, that, supposing, with the author, the great faults bounding this district on the west to have been anterior to the Magnesian Limestone, it would seem extremely improbable that they should have been anterior also to the first movement which broke up the Coal-measures; for, in such case, these enormous dislocations would be unconnected with any great movement in the surrounding district,—a conclusion which, to any geologist acquainted with them, must I conceive appear incredible. I make this remark in consequence of the date which, as we shall see hereafter, M. de Beaumont assigns to the elevation of Cross Fell. The Ashby de la Zouch coal, on the borders of Charnwood Forest, is overlaid unconformably by Triassic beds, as is likewise, I believe, the neighbouring field of Warwickshire. In both cases the strikes are parallel to the central axis of Charnwood Forest, about 30° W. of N. In the Ashby de la Zouch field the Magnesian Limestone is wanting.

In the Dudley coal-field the Permian beds are developed in great thickness, but without any distinct bed of Magnesian Limestone. Sir R. Murchison states that its lowest portion rests *conformably* on the coal strata, and has been elevated with them. The geologists of the Survey, however, have recognized distinct indications of discontinuity between these formations, but still of that amount only which would not be detected by examination of the surface of junction in any one limited locality. Thus, whether we allow this discontinuity or not, we may still assert that no great dislocating movement can have taken place in this district before the middle of the Permian period. Another must have taken place before the conclusion of the Triassic period, for beds of that period in the northern part of this field repose unconformably on the beds of coal. It is probable, however, that the great dislocating movement here took place *after* the Triassic period. The coal district is bounded on the east and west by great faults which are continuous from one end of it to the other, that on the western side having been traced, moreover, into the New Red Sandstone to the north, and many miles to the southward into the Lias, where it dies away. It dislocates this latter formation, and must therefore have been posterior to it, at least in its southern portion. Along the boundaries of the field itself, it dislocates the

Triassic beds, to which at least, therefore, it must have been posterior. Further, many of the transverse faults, which are numerous, run directly to this great longitudinal fault, but *cannot be traced beyond it*, showing clearly that those transverse faults cannot have been *anterior* to the longitudinal fault. The great dislocating movement of this district *must*, consequently, have been posterior to at least a large portion of the Trias, and *may* have been *posterior* to the Lias.

In the more northern portion of this coal-field the strike is N.N.E., and in the more southern N.N.W., presenting the appearance of two lines of elevation crossing each other at an angle of about 45°. If however we consider the characteristic direction of the great movement of this district as determined by the mean direction of the great boundary fault above described, the orientation will be a few degrees E. of N. and W. of S.*

This conclusion agrees with that deduced from the Nottingham and Derbyshire Coal-field with reference to a decided movement, at least considerably after the commencement of the Triassic period, and possibly after its conclusion.

In Coalbrook Dale the general direction of the main dislocations is given as N.E. and S.W. by Sir R. Murchison and Mr. Prestwich, who both recognise the lower Permian beds as graduating into the Coal strata. The latter gentleman also considers that there is a discontinuity between the Triassic and Permian groups which Professor Ramsay also recognizes generally in this region. Hence the principal movement which dislocated this district must have been after the lower Permian beds, and the best approximation, perhaps, we can make to its epoch, is to refer it to the discontinuity above-mentioned between the two great divisions of the Red Sandstone series.

In the coal-field in the neighbourhood of Bristol the disturbed beds of the coal-measures are covered unconformably by the Dolomitic Conglomerate of that neighbourhood. This conglomerate was formerly referred by geologists generally to the same period as the Magnesian Limestone of the North of England, as being the only bed in this region which could be regarded as the equivalent of that formation.

Later observations of the geologists of the Survey have left this point still undecided, but have tended to invalidate the opinion formerly entertained.

M. de Beaumont considers himself at liberty to place this Conglomerate at the bottom of the Trias. This would assign the same epoch to the movement in the Bristol Coal-field as that above supposed for Coalbrook Dale. Instead, however, of being N.E. and S.W., the direction is here nearly N. and S.

With respect to the Salopian coal-fields it may be sufficient to state, that the general directions of dislocation are nearly N.E. and S.W. In Denbighshire the Carboniferous Limestone and coal-measures wrap round the Silurians of that region, on the eastern side, their

* During the preparation of these sheets for the press, I have been indebted to Mr. Jukes for a copy of part ii. vol. i. of the 'Records of the School of Mines,' containing his description of the Dudley coal-field. It is confirmatory of what Prof. Ramsay has had the kindness to communicate to me verbally.

strike varying in direction from a few degrees E. of N. on the southern, to N.W. on the northern part of their range. I am not acquainted with the evidence by which the movements which have affected them may be dated.

The last Coal-field I shall notice is that of S. Wales. The date of its great movement, if we are to refer its dislocations to one such movement alone, is considered to be the same as that of the Bristol coal-field as determined by means of the Dolomitic Conglomerate. If we adhere to the opinion that the age of the Conglomerate is the same as that of the Magnesian Limestone of the northern counties, we have no evidence to separate the epoch of the movement in that region, of which the characteristic direction is N. and S., from that of S. Wales in which the direction is E. and W. If, on the contrary, we adopt the view of M. de Beaumont and assign the Conglomerate to the commencement of the Triassic period, we have no means (as above remarked) of distinguishing its epoch from movements at Dudley or Coalbrook Dale producing nearly northerly or north-easterly directions. In either case, moreover, this epoch cannot be separated from that of the Bristol district, in the northern and larger portion of which the direction is N. and S.

Let us now return to our author's systems, and examine their applicability to the phænomena of the districts which we have briefly passed in review. His first four systems, those of *La Vendée*, *Finisterre*, *Longmynd*, and *Morbihan*, are all regarded as probably antesilurian, but so far from its being possible to prove the different lines of elevation referred to them to be respectively contemporaneous, the chronological order of the systems themselves cannot be determined with any certainty. They can only, therefore, be severally regarded as systems of parallel lines, the contemporaneity of which admits of no independent proof. I may also observe, that the Longmynd has been, I think, unhappily chosen as the type of one of these systems. Those rocks appear to be referable to the lower part of the series of N. Wales, where the strike of the Longmynd system never presents itself. The district of Longmynd too is of small extent, and lies upon a line of volcanic eruption running in a N.E. and S.W. direction. Volcanic action appears to have been frequent and violent there, and it is probably to that action that the highly disturbed state of the Longmynd beds and the abnormal direction of their strike are to be attributed. This does not prove the non-existence of the system elsewhere, but I am persuaded that the Longmynd has no claim to be made the base on which it ought to rest. The other three of these systems are founded on observations made in North-western France.

The next system recognized by our author is that of *Westmoreland*. He appears to consider the Tilestone as equivalent to the lower division of the Devonian series, more developed in certain continental localities. The epoch of this system, therefore, supposed to be immediately after the Tilestone, corresponds, according to this view, to the middle of the Devonian and not to the conclusion of the Silurian period, this latter epoch not being recognized as one of those at which any system has originated. The same remark applies to the

epoch between the close of the Lower and the commencement of the Upper Silurian periods, at which there is distinct evidence in Wales of a movement having taken place, though not one generally of great magnitude. According to any theory of elevation it might probably appear remarkable that no movement of a distinctive character should have taken place at either of the above epochs, at which such remarkable transitions took place in the types of organic life over a large portion of the globe, but it would seem especially remarkable when viewed with reference to a theory admitting so few epochs of disturbance.

This system is probably the best defined of any of those European systems recognized by M. de Beaumont. It undoubtedly exists over a large portion of the Palæozoic rocks of these islands, admitting local deviations in the directions of strike to a considerable amount, as must be done, if we include in the system both the S.E. of Ireland and the Grampians. It is important here, however, to recollect, that this movement can have produced scarcely an appreciable effect, as I have already shown (p. lxxiv), in the region of S. Wales and the adjoining counties of England. We may also observe that its epoch is widely separated from that of any anterior or posterior recognizable great movement.

The system of the *Ballons* (mountains in Alsace) is our author's next system in order of time. He supposes it to have been produced between the periods of the Carboniferous Limestone and Millstone Grit. The age of this system, and consequently the contemporaneity of the lines composing it, appear to me very unsatisfactory. I cannot recognize in this country any movements of this epoch, because I believe that no example has ever yet been observed of a sensible unconformity between the Mountain Limestone and Millstone Grit in these islands, at any point where the junction of the two formations is visible. There may be *overlaps* of the superior formation, but not such as to indicate an appreciable difference in the dips of the beds of the two formations in the same locality. I cannot, therefore, agree to refer, for example, the great disturbance in the valley of the Dee in N. Wales, on the north of the Berwyns, to a movement at the epoch in question, while I believe the Millstone Grit and Carboniferous Limestone to be in perfect conformity within a few miles of this locality, and in every other part of these islands. The author refers to phænomena in the immediate neighbourhood here spoken of, for the establishment of the epoch of this movement; but on consulting the Ordnance Geological Map, instead of the imperfect maps which he appears to have consulted, it is easily seen that no discontinuity between the two formations in question is indicated. But the epoch of this system is avowedly doubtful.

The system of *Forez* dates, according to our author, between the Millstone Grit and the Coal-measures. It is founded on observations of dislocations in the mountains of Forez in the department of the Loire. In this country the system is supposed to embrace the anticlinal which runs N.N.W. in the southern part of the Dudley coal-field, as already described (p. lxxvi), Cross Fell, Derbyshire, and one or

two other localities. The leading objection to its application to this country, is like that which I have made to the system of the Ballons —we have no appreciable discontinuity between the Millstone Grit and the proper Coal-measures, beyond those occasional overlaps which would at times be the necessary consequence of those small and often-repeated movements of depression, which, as it has been already shown, must have attended the deposition of thick sedimentary masses, but leaving no sensible angle between the lower beds and those deposited immediately upon them. Such movements are not, I presume, to be classed with those convulsions in which we may recognize the origin of *systems* like those of our author. With respect to the Dudley N.N.W. anticlinal, it will appear, I think, from what has been above stated (p. lxxvi), that it must have been produced after the deposition of the lower Permian rocks. If the evidence on which this conclusion rests be rejected, it would be extremely difficult to say what evidence on such points ought to be admitted. With respect to the period of elevation of Cross Fell, all analogy with the whole region on the south of that range, would lead us to conclude that the movement was posterior to the Coal-measures (p. lxxvi). The application of this system to the great mass of Derbyshire is unquestionably inadmissible.

It appears to me difficult to recognize any distinct traces of the system of Forez in this country.

We now come to our author's eighth system, that of the *North of England*, of which the characteristic direction is nearly N. and S., and the epoch between the Coal-measures and the Rothliegendes, the lowest portion of the Permian formation. This is an important and well-defined system in this country. It will appear from what I have already said (p. lxxv), that many of the leading phænomena of the coal-fields of Derbyshire and the North of England are referable to it. At the same time it does not appear to have produced any material effect in the South-west of England and in S. Wales, supposing the Dolomitic Conglomerate to have been posterior to the Magnesian Limestone.

The ninth system is that of the *Netherlands and S. Wales*. M. de Beaumont places it after the Magnesian Limestone, and before the Dolomitic Conglomerate of Bristol and the Grès des Vosges, which he makes immediately antecedent to the Grès bigarré of the Trias. Its direction in S. Wales is very nearly E. and W. Its extension into the south of Ireland is apparent in the E. and W. anticlinals which affect the Old Red Sandstone and Carboniferous Limestone of that region.

In Wales and the adjoining counties of England, M. de Beaumont has restricted this system principally to the southern part of the Principality, though recognizing more doubtful indications of its influence in one or two other localities. It appears to me, however, demonstrable, that whatever movements elevated and dislocated the Coal-measures of S. Wales and those of Denbighshire produced also by far the greater part of the phænomena of elevation throughout the whole of the region now referred to. The proof rests on the

small amount of unconformity in the stratification throughout that region between the lowest beds and the Coal-measures inclusive, as already stated.

The most obvious way of judging of the importance of this movement, is to replace in imagination the whole sedimentary mass in the position which it occupied immediately anterior to the movement. For this purpose we have only to conceive the inclination of the beds of every formation to be changed at each point throughout the whole area, to an amount which should render the Coal-beds horizontal. At those points where Coal-strata do not now exist, we must judge of the corresponding amount of change to be given to the inclination, by means of the continuity and other circumstances of the stratification, exhibited in passing from those points where the Coal-beds do exist. Now it follows from the facts already insisted upon, that the beds of the whole series of formations in S. Wales would thus be brought into a position in which their inclination to the horizon would be so small that the eye would probably be unable to detect it. I am not acquainted with the amount of discontinuity in Denbighshire, but I venture to assert that it is small compared with the actual inclination of the beds of Coal and Mountain Limestone; and if so, the Silurian beds of that region would be reduced to approximate horizontality if the exact horizontality of the Coal-beds were restored. Such would be the case also in the neighbouring counties of England where Coal is found; and such also we may conclude, by the most legitimate induction, would be the case approximately at those points where Coal does not now exist, always excepting those limited localities in which the beds may have been disturbed by local volcanic action. It is only in this manner that we can form an accurate conception of the enormous influence of the movements subsequent to the Coal period, in producing the observed phænomena in the region of which we are now speaking.

Another strong reason for supposing the great movement of N. Wales to have been subsequent to the Coal-measures, is to be found in the fact already stated (p. lxii), that those measures are dislocated by the great Dolgelly and Bala fault, at its north-eastern extremity.

But if the disturbances throughout N. Wales and the adjoining region are to be referred principally to the same epoch as those of S. Wales, how shall we account for the various directions of the numerous lines of elevation which this part of the country presents to us? This is a grave difficulty in M. de Beaumont's theory. To account for such facts, as well as for the existence of *curvilinear* lines of elevation, our author has recourse to the notion of *mixed systems*. They are supposed to arise, if I understand him correctly, either, in the first place, from the resulting effects of *successive* movements on the superficial strata in which we observe the phænomena; or secondly, from a single movement acting on such superficial strata, the mechanical cause producing the movement being modified in its operation by the previously dislocated state of the subjacent portion of the whole mass, caused by anterior movements in directions different from that of the movement which alone has affected the superficial beds.

In S. Wales and the adjoining counties of England, the directions of the lines of elevation vary from a few degrees S. of E. to several degrees N. of N.E., and, moreover, all the lines between Cardigan Bay and the anticlinal ridge of the Towy are regularly and continuously curved. To account for these anomalies our author has recourse to the anterior systems of *Finisterre, Westmoreland,* the *Ballons,* and *Forez,* combined with that of the *Netherlands,* the one we are considering. The influence of the system of *Finisterre,* supposed to be ante-silurian, in this region is merely hypothetical, and I have proved that the movements which produced the other three anterior systems (all of which are post-silurian) must here have been inappreciable, because the Silurian beds must have remained sensibly horizontal till the disruption of the Coal-measures. There could not, therefore, be any pre-existing dip of sufficient amount to modify materially, according to the first of the above-mentioned suppositions, the powerful movement which elevated S. Wales and extended, as I conceive, throughout the whole of the Principality and the neighbouring district.

When a mixed system, or one whose direction is *borrowed* from a previous one, is supposed to arise from a modified action of the cause producing it, according to the second of the above-mentioned suppositions, we must assume lines of elevation to be more easily produced in the directions of pre-existing lines than in any other, or, in other words, we assume those lines to be *lines of least resistance.* If the acting cause be a force *extending* the mass acted on, and the pre-existing lines have originated in *fissures,* the above assumption will necessarily be true, and I have elsewhere investigated the influence of such pre-existing fissures on the formation of subsequent ones. But when the acting force is a *compressing* one, and the previous lines of elevation have originated in *compression,* it by no means follows that those lines will be lines of least resistance to a subsequent *compressing* force. It is just as possible, I conceive, that they might become lines of *greatest* resistance. Any conclusions deduced from the assumption of their being lines of least resistance could not, I think, be satisfactory. I cannot, therefore, attribute any material influence of this kind on the great elevatory movement of this district, to any anterior recognizable movement which can have taken place in it, and I cannot, therefore, regard these explanations of the phænomena of elevation of S. Wales as at all satisfactory.

The tenth system of our author is that of the *Rhine.* Its epoch is immediately anterior to the Trias, and appears to be very well defined by the phænomena in the Vosges Mountains, on which the system is founded. It would seem, at least, that, in the continental localities where it is supposed to manifest itself, its epoch cannot be later than that just mentioned. Its orientation in the west of England is about N. 13° E. M. de Beaumont supposes it traceable in the northern part of the Dudley coal-field, from the direction of which, however, it differs by about 9°; and, moreover, the principal disturbance there has been proved, as I have already shown (p. lxxvi), to have been posterior to a large part of the Trias, at least, and the

great fault bounding the district on the west (to which our author alludes) has been traced southwards into the Lias which it dislocates. This system is also supposed to show itself in Coalbrook Dale; but there the general direction is nearly the general north-eastern direction which characterizes the surrounding region. Again, the N.N.E. strike of the south-eastern part of Ireland is supposed to indicate its influence; but Sir H. De la Beche asserts that strike to be due to a movement anterior to the Old Red Sandstone*. Other applications of the system to this country appear to me too vague to be of much value, unless they were sanctioned by more determinate cases in the same region than any which the author has cited.

The eleventh system is that of *Thüringerwald*, between Bavaria and Bohemia, where it appears to be most distinctly developed. Its orientation there is about W. 39° N. Its epoch seems to be well defined between the *Marnes irrisées* (the latest formation of the Trias) and the earliest beds of the Lias. Indications of this system exist to a considerable extent in France, but scarcely any applications are made of it in this country. It is suggested, however, that faults may belong to this system *perpendicular* to its characteristic direction. In support of this supposition, reasoning of my own is quoted, in which I have shown that systems of *fissures* perpendicular to each other might be formed simultaneously. But I must repeat what I have already stated (p. lxxxi), that that conclusion is only true when the action is that of forces of *extension*, and not at all necessarily so when the forces *compress* the mass on which they act. Such perpendicular or *transverse* faults would nearly coincide, it is said, in direction with the great fault on the western side of the Dudley coal-field, which, therefore, might be connected with this system. The author had previously referred it to the system of the Rhine, as above stated.

The period which intervened between the deposition of the Coal-measures and the commencement of the Lias, during which the Permian and Triassic groups were formed, was one of great disturbance. The last four systems, it will be observed, are referred to this period. The first of these, that of the North of England, seems very well to represent the movement antecedent to the lowest Permian beds. The epoch of the second, that of the Netherlands and S. Wales, is subject to great uncertainty, as depending on that of the Dolomitic Conglomerate. Its separation, also, from the succeeding system, that of the Rhine, merely by the supposed intervention of the same uncertain formation, is unsatisfactory. The last of these four systems, that of *Thüringerwald*, is the only one after the commencement of the Trias, but is altogether insufficient to represent with that accuracy to which the theory aspires, all those lines of elevation which resulted from movements subsequent to that epoch in our own country.

The next system is that of *Mont Pilas* and the *Côte d'Or*. The former mountain is situated in Forez, in the department of the Loire. The epoch of the system is between the Oolites and Lower Green Sand. It is recognized in the eastern and some other parts of France,

* Memoirs of the Survey, vol. i. p. 222.

and in Germany, and M. de Beaumont supposes that the Oolitic escarpment of this country may be due to it. This last conclusion is manifestly very vague.

The thirteenth system of our author is that of *Mont Viso and Pindus*. The former is a mountain in the French Alps. The epoch of the system is placed immediately after the Lower Cretaceous formation, including the Firestone of the Upper Green Sand in Kent, and the *Craie chloritée* and *Craie tufeau* of the French. It appears to have been chiefly recognized in Central France and Greece.

The system of the *Pyrenees* presents itself next in the order of time. Its direction is W.N.W. and E.S.E. Its epoch is immediately after the Nummulite formation. It appears to have no representative in the interior of France or in the Peninsula, but is widely developed more easterly in southern Europe. The elevation of the Weald and the Bas Boulonnais is also partly assigned to this system.

I have given a very detailed description of the geological structure of the Weald and Bas Boulonnais in a paper which is the last published in the 'Transactions' of this Society. The lines of elevation in this district being *curved* lines, present the difficulty of which I have already spoken in M. de Beaumont's theory. He endeavours to meet it by assigning the elevation of the Weald to three distinct epochs, so that it forms, according to this view, a part of three different systems—those of the *Côte d'Or*, the *Pyrenees*, and the *Isle of Wight*. My great objection to this view is, that it rests on the gratuitous assumption, for which not the slightest independent evidence is offered, that different portions of this district were elevated at different epochs, at which their respective lines of elevation were produced. The dislocations of the Bas Boulonnais are referred to an ante-cretaceous period; those of the south-eastern part of the Wealden to that immediately preceding the Plastic Clay; and the lines of the more eastern portion, extending into Wiltshire, to the period of the middle Tertiaries. Of the two first assumptions there is no proof whatever, except that deduced from the theory of parallelism itself. At the same time there exists throughout this district as complete a *character of continuity* as in any district with which I am acquainted; and if we are ever to reason on the principle that unity of character in observed phænomena must be regarded as indicative of a corresponding unity in the cause to which those phænomena are to be attributed, this is not, in my opinion, a case in which we are at liberty to deviate from that obvious rule for the guidance of our philosophical speculations. The district is a limited one, and its lines of elevation are consequently placed in close juxtaposition; their parallelism, so far as the term can be applied to curved lines, is probably more nearly exact than in any one of the systems to which our author would refer them; and there is no evidence, as I have already remarked, to authorize our referring them to three distinct epochs. And yet, according to M. de Beaumont's theory, phænomena thus closely allied are to be allowed no claim to a common

origin, but are to be entirely dissociated and united with others, the nearest of which, in the system of the Pyrenees, are separated from them by many hundreds of miles, and only united to them by a parallelism not less conventional than that which unites them as curved lines among each other. To justify this view of the phænomena of the district of the Weald and the Bas Boulonnais, the author cites the cases of the Alps, the Pyrenees, and Wales, as those in which different systems intersect each other. If there be evidence, *independent of mere direction*, that these systems are referable to different epochs, and are therefore really so many distinct systems, there cannot be the slightest difficulty in admitting the conclusion; but I should deny its validity with reference to the Alps or the Pyrenees, as I have already done with respect to Wales, if those mountains presented in their phænomena the same simple unity of character as the district of the Weald and Bas Boulonnais. I feel myself bound here to remark, that our author speaks, perhaps too habitually, of systems which are only known to be characterized by *parallelism*, as if they were equally known to be characterized by *contemporaneity*.

It is not my object, as I have before assured you, to direct your notice to my own particular theories, but when I am contending against the notion of referring phænomena, with an obvious character of unity, to several successive movements, I am anxious not to be misunderstood. The repetition which I object to is that of movements, each of which would produce phænomena *characterized by a different law* (or, in such cases as those of which we are now speaking, by *different directions*), when such repetition is arbitrarily assumed merely to account for phænomena connected by a distinct unity of character. I should myself, also, generally refer phænomena of elevation so connected to several successive movements—one principal one which has impressed the characteristic law which connects the lines of elevation, and other subordinate movements, which may produce additional lines subject to the *same laws* as the phænomena resulting from the principal movement, and not following different laws as supposed by our author in the case we have been discussing.

The fifteenth system of M. de Beaumont is that of *Corsica and Sardinia*, where its direction is N. and S. He divides the Tertiaries of France into three groups, the *Grès de Fontainebleau* being the base of the middle one. The epoch of the present system immediately precedes the deposition of that formation. It is recognized in central France, in Hungary and Syria, but not, I believe, in this country. It was succeeded by the system of the *Isle of Wight and Tatra*. The epoch assigned to the latter is that between the deposition of the *Grès de Fontainebleau* and that of the Upper Freshwater Limestones in the neighbourhood of Paris. Its direction is a little N. of W. and S. of E. I have already expressed my opinion against the dismemberment of the well-defined system of lines of elevation of the south-east of England, to which I consider the great dislocation of the Isle of Wight and the Isle of Purbeck, included by M. de Beaumont in the present system, to belong. He also recognizes this system in Hungary, Turkey and Greece, as well as in various parts of the Alps and the

Jura. The proof of contemporaneity of the phænomena in these different localities is necessarily imperfect from the circumstance that the *Grès de Fontainebleau* does not extend beyond the Paris basin, and no exact equivalent of it elsewhere has been determined.

The next system, that of *Sancerrois* in the south of France, is recognized also in Greece. Its epoch is supposed to be between the end of the deposition of the Upper Freshwater Limestones of the Paris basin, and the *Faluns* of Touraine. The system, however, does not appear to be very determinate.

The Alps are considered by M. de Beaumont to be the combined result of several successive movements. The earliest of those of which he there recognizes the influence, is that which produced the system of *Mont Viso* during the Cretaceous period. He considers the system of the Pyrenees, which elevated the Chalk and Nummulite formation, to be frequently traceable, in several portions of the Alpine chain. Then came the system of *Corsica and Sardinia* and that of the *Isle of Wight*, both anterior to the Mollasse, immediately subsequent to the deposition of which came the movement which produced our author's eighteenth system, that of the *Western Alps*. Its epoch, therefore, corresponds to the completion of the middle Tertiaries. The surrounding region then became occupied by extensive lakes, in which was deposited the *terrain de transport ancien*, at the period of the Upper Crag of this country, on the dislocated beds of the Mollasse. This *terrain de transport* was in its turn broken up by the great movement which gave its present form to the principal chain of the Alps (extending eastward from the Vallais), and produced the system which thence derives its name. Both these Alpine systems are of wide geographical extent, and the latter especially comprises some of the greatest dislocations to which southern Europe has been subjected. It extends also, according to our author, into northern Africa. In this country we have no traces of either of them sufficiently determinate to demand particular notice.

The latest system recognized by M. de Beaumont is the *System of Tenarium, Etna, and Vesuvius*. It is founded principally on observations in Greece, but comprises the volcanos of Etna and Vesuvius, through which its *great circle of reference* is assumed to pass, in a direction a few degrees W. of N. and E. of S. It is by means of this line that our author has fixed the position of his pentagonal *reseau*, one great circle of which (DH) has been assumed to coincide with it.

The systems of which I have given this brief sketch are those which M. de Beaumont most distinctly recognizes in Europe, but they are not restricted, according to his views, to this quarter of the globe. He traces several of them into Asia, Africa, and America. I shall not, however, attempt to follow him into these distant regions, for my object has been to bring before you a part of the evidence on which the truth of his theory rests, and it is manifest that such evidence can only be sought in those regions with the geological structure of which we are best acquainted. When we shall be satisfied of the truth of the theory in its application to Western Europe alone, it

may be time to enter into a critical examination of the vaguer evidence on which its extension to other quarters of the globe must necessarily rest. I may here, however, mention one conclusion of our author, which, to those not previously acquainted with it, will probably appear somewhat startling. The very recent date assigned by him, not merely to minor movements in the Alps, but to those which were principally instrumental in giving its actual form and altitude to that magnificent chain, will probably have surprised many geologists; but it is a far bolder step to assert, with M. de Beaumont, that the whole range of the Andes may probably have been elevated since man became an inhabitant of our globe, and that the *deluge* may have been the consequence of its upheaval. Such conclusions can only rest on the immense relative importance assigned to the latest movements to which these great mountain ranges have been subjected in comparison with the earlier movements which may have affected them, and to which, for aught that is shown to the contrary, they may really owe by far the greater part of their elevation. But this latter view would be altogether inconsistent with the general principle of instantaneous elevation which forms the basis of M. de Beaumont's theory.

The great defect in the evidence adduced by M. de Beaumont in support of his theory is in the want of independent proof of the *synchronism* of lines of elevation referred to the same system. A general synchronism in the periods of great disturbance throughout such a region as Western Europe, or even throughout regions of greater geographical extent, is not difficult to establish on the best evidence which geological phænomena can afford us; but when we attempt to determine the exact relative dates of the particular movements of each period, we find ourselves beset with numerous difficulties. I have brought before you a sufficient number of facts respecting the palæozoic periods to exemplify these difficulties in our own country, and if they exist here, what must be the amount of uncertainty in other regions in which the geological structure is comparatively so imperfectly known! Again, these relative epochs during the Tertiary period must necessarily be of extremely difficult determination, on account of the small areas over which each separate formation of that period preserves any character of continuity, and the consequent difficulty of establishing in one district the exact equivalent of any proposed formation in another. I need scarcely remind you of the exemplification of what I am now stating afforded by the tertiary basins of the North of France, Belgium, and the South-East of England, situated as these basins are in close contiguity with each other, and subjected as they have been to long-continued and searching investigation. Such considerations render it almost certain that M. de Beaumont's theory, as now expounded by him, must receive many modifications, and it still remains to be seen how far the changes which extended inquiry may demand, can be made consistently with the fundamental principles of the theory. The author has already been obliged to make modifications in consequence of our advancing knowledge. The date of the elevation of the

Pyrenees and of certain central portions of the Alps was originally supposed to be earlier than it is now proved to have been; and this change of date must be extended, in accordance with the theory, to all those chains which belong to the *System of the Pyrenees**. These and similar considerations afford no positive proof that M. de Beaumont's theory is wrong—they are not now insisted on with that meaning—but they do show the imperfect evidence on which it depends, and the necessity for the greatest caution and reserve in accepting it in any degree of generality approaching that which its author would assign to it.

There is another remark which must not be omitted in speaking of the evidence hitherto adduced in support of this theory. M. de Beaumont has brought forward many cases of parallelism, with comparatively few of well-ascertained synchronism; but allowing the cases of assumed, to be cases of real synchronism, it still remains to be seen what cases there may be of *synchronism without parallelism.* Parallelism without synchronism might perhaps be regarded as the consequence of the *recurrence of direction,* but the converse is irreconcileable with the fundamental principles of the theory. It is true that M. de Beaumont recognizes directions as partly derived from anterior movements (*directions d'emprunt*), but his mechanical explanation of them is not in my opinion at all satisfactory†.

Both North and South Wales and several of our coal-fields offer examples of this kind. If the frequent recurrence of similar examples shall be hereafter established, it will necessarily, I think, be subversive of the theory, except in its far more restricted application. Hitherto little attention has been given to such cases with reference to this theory.

The preceding remarks apply to the evidence which has been, or may hereafter be adduced for or against this theory. With respect to the theory itself I may further observe, that it involves two extreme conclusions which can never, in my opinion, be brought within the limits of legitimate induction from observed phænomena: I mean that of the *instantaneous* elevation of mountain chains or lines of elevation generally; and that of the extension of any parallel system to parts of the earth's surface between which no geological continuity whatever is traceable.

The narrowest limits between which we can possibly, from the nature of geological evidence, restrict the periods of certain movements, are far too wide to sanction the first-mentioned conclusion as expressing an essential character of each movement. The *legitimate induction,* without its being a *necessary conclusion,* would be, I conceive, that movements, greater or less in number and magnitude, had taken place within certain determinate limits of time. I entertain no faith in either of the extreme hypotheses—that which would reduce their number to unity, or make it indefinitely great. But this is a question to be discussed on independent evidence. The second of the above conclusions—that which relates to the wide extension of

* Sir C. Lyell's Principles, p. 165, Eighth Edition.

† Page lxxxii.

each system—involves the hypothesis, that formations in one part of the globe, which may, in general terms, be asserted to be the equivalents of those in some very distant regions, were synchronous with them in deposition, and to a degree of exactness which I cannot but regard as exceedingly improbable in itself, and which cannot possibly be established on direct geological evidence. This conclusion of our author also involves, as I have before remarked, the dismemberment of local systems of lines of elevation (such, for example, as those which exist in the south-east of England and in several of our separate coal-fields, and other particular districts), presenting far more obvious characters of unity than those systems into which this theory would group them. Thus two faults or anticlinals, of which the directions may differ by not more than 10° or 12°, though the one may be an actual continuation of the other, must have their family ties broken, and be respectively associated with others of their class of very doubtful relationship. Proximity in geological phænomena, though not a necessary, is assuredly a presumptive proof of unity, and when uncontradicted by direct evidence, must be received as a strong indication of it. A difficulty like that which I am now discussing, might undoubtedly disappear before exact and positive evidence, but, considering the necessary character of geological evidence on such points, it must, I think, ever remain, even under the most favourable circumstances, a grave obstacle to the reception of the theory in the form in which it is now propounded.

I have before remarked, that M. de Beaumont's theory must be established or refuted by the observation of phænomena and not by abstract dynamical reasoning, but that geologists will still necessarily look to its mechanical significance. The physical cause to which our author refers the phænomena of elevation—the shrinking of the earth's crust—is that which appears to me most unlikely to produce that paroxysmal action which his theory so essentially requires, and most likely to produce those slow and gradual movements which it scarcely recognizes. The actual depressions of the great oceanic basins, and, generally, the more widely extended geological depressions of the present or former periods, may, I think, be referred with great probability to this cause; but I feel great difficulty in tracing to it the sudden and violent efforts required to produce paroxysmal movements, for which *explosive* action, similar to the volcanic action of the present time, though on a far larger scale, seems to me to offer so much more satisfactory an explanation. The enormous outpouring also of molten matter which must have accompanied the greater disturbances of the earth's crust would seem thus to be more easily explained, for the general tendency of the squeezing and compression of the crust must be to close and seal up those vents by which molten matter might escape from beneath it. M. de Beaumont himself would seem to be aware that sudden collapses of the crust could only be consistent with its extremely small thickness; but I am surprised at his adopting the hypothesis of its actual thickness not much exceeding thirty miles, without any reference to the proof

which I have offered long ago, that so thin a solid shell would be inconsistent with the well-ascertained amount of the precession of the equinoxes; or, especially, without reference to the possible effect of pressure, on the temperature of fusion of the different substances of which the earth's crust is composed. I have long since insisted on the importance of careful experiments on this subject, and I am happy to avail myself of this opportunity of making to the Committee of the Royal Society for the disposal of the annual grant of the Government in aid of scientific researches, my acknowledgement of their liberality, by which I have been enabled, in conjunction with my friends Mr. Fairbairn and Mr. Joule, to institute the experiments alluded to. I am now able to state, that with respect both to the temperature of fusion and the conductive power of various substances under great pressure, we are obtaining clear and determinate results, which must form essential elements in future calculations or general speculations respecting the interior of our planet. When our experiments shall be completed, I may again, perhaps, enter upon speculative researches of this nature.

I have now, Gentlemen, discussed this subject, I trust sufficiently to enable you to form your own opinions respecting the *theory of parallelism* as now advanced by the distinguished French geologist. That the phænomena of elevation within certain districts are usually connected by some geometrical law, and that such law is frequently that of parallelism, I conceive to be beyond all doubt. And, moreover, I think it almost equally beyond reasonable doubt, that the phænomena thus connected may be considered as contemporaneous, not necessarily in M. de Beaumont's absolute sense of the term, but at least as regards the principal of those movements to which the phænomena are referable. That the law of parallelism, however, especially as restricted to *straight* lines alone, is the only law which may characterize a system of lines of elevation, I cannot admit. The law of *divergency* may in some cases be distinctly recognized, as in the Lakes district of the North of England; and I have already pointed out to you* that the great circles of our author's *fuseau* are really diverging and not parallel lines. But to what extent, then, are we to accept M. de Beaumont's theory? So far, I reply, as we may deem it founded on a legitimate induction from observed facts. However we may be allowed to speculate beyond that boundary, no theory not comprised within it has a right to be received, except with that reserve which may leave us free ultimately to adopt or reject it according to the suggestions of more enlarged experience.

I regret that time absolutely forbids my entering into any analysis of the various communications which have been made to us during the past year. The subject which I have been discussing has led me to analyse a considerable portion of what has been done by geological observers in this country with respect to the structure of our palæozoic districts, but I could have wished also to enter more fully into details which have been recently brought forward by Prof. Sedgwick, Sir R. Murchison, Mr. Sharpe and others. I have also felt desirous of bringing under your particular notice the excellent paper of Sir C.

* Page lvi.

Lyell on the Tertiaries of Belgium, together with a brief review of the labours of other geologists in this department, among whom I may particularly mention our associate Mr. Prestwich, whom we have so much reason to regard as one of the best authorities in Tertiary geology, and whose papers exhibit so excellent a combination of careful observation and cautious philosophical induction. But I may, perhaps, be allowed to express the hope that the subject may fall into the abler hands of the distinguished geologist whose accession to the Chair which I have had the honour to occupy, we all hail with so much satisfaction. I regret also to pass over Mr. Logan's paper *On the Potsdam Sandstone Footprints*, and Prof. Owen's clear and beautiful explanation of them, with no further notice than the bare mention of them. But for these and other like omissions I can only again plead the excuse of want of time and the length to which this Address has already extended.

I cannot close this Address without a word of congratulation on the steady progress of our science, and on the part which our own country, and this Society in particular, are taking in promoting it. The results of our Geological Survey cannot fail to be of vast importance to speculative as well as to practical geology, and forcibly exemplify to us the value of accurate, and the uselessness of vague and careless observation. Palæontology is steadily advancing, though arrived at that stage in which further advance becomes more and more difficult, and only to be made by the most accomplished naturalist and anatomist. The works proceeding from the Palæontographical Society and the palæontologists of the Survey, are embodying and placing within the reach of the geologist an immense mass of palæontological knowledge. And here I must not omit mention of the admirable work done by Prof. M'Coy in the arrangement of the Woodwardian Museum at Cambridge, which is now become so noble a monument to the zeal, the energy, and the liberality of my friend Prof. Sedgwick. There is probably no palæontologist of eminence who is not already acquainted with the description of the Palæozoic Fossils of this museum written by Prof. M'Coy, and recently published by Prof. Sedgwick. I feel it more especially incumbent upon me to notice this work, because I am able to bear personal testimony to the unwearied labour and care with which the writer has prepared it, and the accuracy of the drawings representing some of the more imperfectly known objects in the museum. Prof. M'Coy, also, has not forgotten that when the palæontologist has described all the species of a great collection, his work may yet be imperfect without those facilities of references which the geologist may frequently require. He has not only given a systematic list of the Lower Palæozoic fossils with references to their localities, but also an alphabetical list of all the localities, with an enumeration of the fossils derived from each of them. All aids of this kind which can be derived from tabular arrangements become of the greater importance in proportion to the accumulation of palæontological facts and geological requirements.

That department of our science which depends on the application of mechanical and physical principles, though gradually advancing, has been, and still remains much slower in its progress than that which depends on the natural sciences. The primary reason of this is probably to be found in the essential difficulty of the physical and dynamical problems of geology; but another reason presents itself in the fact, that while so many accomplished naturalists have devoted themselves to the study of geology, so few persons, whose primary studies have been those of mechanical and physical science, have paid any attention to the subject. The consequence is, that not only is the advance of the science comparatively slow in the suggestion and solution of new physical problems, but that vague and not unfrequently erroneous notions with respect to those problems which have been long discussed and investigated, are still too current amongst us. It is especially to be regretted that chemistry has hitherto done so little for us, though it is doubtless destined to create in geology one of the most interesting branches of the science. But before this can be effected, men with accurate knowledge and enlarged views respecting the nature and operation of chemical principles, must devote themselves also to the study of geology, for without such study they will never sufficiently understand the conditions under which Nature has elaborated her work in producing the vast variety of phænomena of which the external crust of our globe is the great repository. We cannot be too earnest in our endeavours to enlist such men in the cause of our science. We may then hope to see this branch of it advancing in a degree commensurate with the progress of those branches to which the attention of geologists has been hitherto more especially devoted.

And now, Gentlemen, having performed the last duty of my presidency, let me again express to you the sense I entertain of the honour you conferred upon me in electing me to the office, and of the kindness and courtesy I have received from you during my tenure of it. To those gentlemen who have served on the Council of the Society during the last two years, I owe my especial thanks for the prompt assistance I have uniformly received from them in the performance of my duties. And finally, Gentlemen, I would congratulate you on your choice of a successor to the chair which I now vacate, for we can only regard him as one who cannot fail to perform the duties of his office in a manner honourable to himself and conducive to the best interests of the Society.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

NOVEMBER 3, 1852.

Thomas Davidson, Esq., was elected a Fellow.

The following communication was read:—

On the separation of the CARADOC SANDSTONE *into two distinct groups, the* "MAY HILL" *and the* "CARADOC." By the Rev. Prof. A. SEDGWICK, F.R.S., F.G.S.

[The publication of this paper is deferred.]

NOVEMBER 17, 1852.

The following communications were read:—

1. *Notice of the Occurrence of an* EARTHQUAKE SHOCK *in the* AZORES. By T. CAREW HUNT, Esq., H.M. Consul at St. Michael's.

[Communicated from the Foreign Office by order of Lord Malmesbury.]

The following are the particulars of an earthquake felt in the Azores on the night of April 16, 1852; distinguishing the islands from which information has been obtained:

St. Mary's; 0° 32′ East of the point of observation at St. Michael's. Communicated by Major Guerra, a highly intelligent officer of the Portuguese army, resident at St. Mary's, to his correspondent here.

Point of Observation.—The chief town of Villa do Porto, situated on the south-west coast, about 200 feet above the level of the sea, and separated from it by a slightly ascending plain, nearly three miles wide, and W.S.W. (true) of the base of the central ridge, of which the principal peak, Pico Alto*, is 1880 feet in height above the sea.

Time and Phenomena.—At a little more than five minutes after ten ($10^h\ 8^m$ at St. Michael's?), a slight subterraneous rumbling was followed by a sufficiently perceptible oscillation from south to north, ending in a strong shock, and lasting not less than three seconds.

Effects.—No damage appears to have been done to houses and public buildings.

St. Michael's; Point of Observation 25° 41′ West of Greenwich.

Point of Observation.—The chief town of Ponta Delgada, close to the sea, at an elevation of 70 feet, on an ascent which in about three miles reaches to the top of the central ridge of the island, which in this part rises into peaks of between 1000 and 1600 feet above the sea.

Time and Phenomena.—A distinct but not loud rumbling was heard by some persons for about three seconds, and after a perceptible interval, a slight oscillation was felt, rapidly increasing in force, and slightly diminishing at its almost sudden termination. The time was ascertained by the stopping of clocks (which faced to the westward) to be three minutes after ten P.M., and the duration estimated by four persons, watch in hand and independently of each other, at six or seven seconds. The first oscillation, as felt by persons sitting, was thought to be from N.N.W. to S.S.E. (true), and open inkstands were found to have overflowed on their northern and southern sides.

Effects.—The balustrades, pinnacles, and crosses of some church towers were thrown down; a few houses fell entirely, or their roofs or gables fell in, or the walls were rendered unsafe; of others the chimneys and walls were cracked in sides and corners, or the ceilings shaken, or the wrought stone eaves dislodged, and some windows strained, but the glass not broken; many garden walls were shaken down or gapped at the top, or left in a falling condition, and high roadside banks were thrown down. The damage so caused does not appear to have been affected by aspect, situation, or strength of materials and construction. Gaps may be seen in the strongly built corners of garden walls at one side of a road, where loosely built enclosures were left uninjured at the other; and a new farmhouse was entirely thrown down at the west end of the island, surrounded by

* See Mr. Hunt's paper on the Geology of the Island of St. Mary's, Quart. Journ. Geol. Soc. vol. ii. p. 39.

poor huts, of which only a few were damaged. The shock was much less felt at the east end.

Phenomena observed at Sea.—Mr. Wills, the master of the ship Snake, of Portsmouth, then between St. Michael's and Terceira, was sitting in his cabin, when he felt a sudden movement as if the sails were violently shaking in the wind. He ran on deck and found them all full and the movement ceased.

Mr. Ham, the master of the ship Lady Elizabeth, of London, then off the south-west part of St. Michael's, had just lain down, when he felt a shock as if the vessel had run down a boat. He immediately went on deck, but found that the disturbance had ceased.

The earthquake was felt by the crews of the ships in the port, as if their chains had suddenly parted, and by masters going off in boats from the shore; but it was not felt on board ships then close off the east end of the island, nor by one which was twenty miles east of St. Mary's.

TERCEIRA; 1° 33′ West of the Point of Observation at St. Michael's. Reported by Mr. Vice-Consul Read.

Point of Observation.—The chief town of Angra*, close to the sea, at an elevation of about 30 feet, on an ascent which reaches in about two miles to the base of the central ridge of the island, which in this part rises into peaks of between 2000 and 2500 feet above the sea.

Time and Phenomena.—At five minutes before ten o'clock P.M., by Mr. Read's watch (10^h 1^m at St. Michael's?), as well as by the concurrent testimony of his acquaintances, a strong shock was felt which lasted about six seconds, or, as some suppose, from the time occupied by them in rising from bed and going to windows and doorways for safety, about ten seconds. Mr. Read, judging from the motion felt by him and the noise of the walls and roof, remarked at the time that there was a sensible oscillation from north to south, and a round-handled seal in his office was afterwards found to have fallen to the southward. There was no subsequent disturbance.

Effects.—No new damage, with one exception, appears to have been caused by this earthquake; but the fissures of former ones were reopened in several private and public edifices. In one house outside the town, the stone window-sills and the wall under them were cracked on the south side; but the other walls were not injured. No damage has been observed in the walls of gardens, which, as is generally the custom in these islands, are built of loose stones and are about 10 feet high.

Phenomena observed at Sea.—The "Snake" being bound to Terceira, from which place she came to St. Michael's, the master reported to Mr. Read that he had felt the earthquake without knowing what it was. It was also felt by a boat on her way from Pico to Terceira, but not by the ships at anchor in the port.

No subterraneous noise was heard after, during, or before the disturbance.

* For an account of the earthquake that destroyed Praya and injured Angra in 1841, see Mr. Hunt's Communication in the Proceed. Geol. Soc. vol. iii. p. 565.

GRACIOSA; 2° 20′ West of the Point of Observation at St. Michael's. Reported by Mr. Vice-Consul Jones.

Point of Observation.—The chief town, Santa Cruz, situated on the sea at the north side, from which the island gradually rises for nearly two miles to the base of a peak 1226 feet high, forming part of a ridge which divides the island into two parts, one more mountainous than the other.

Time and Phenomena.—The earthquake was very sensibly felt in the southern parts, but in the northern was so slight as to escape the observation of Mr. Jones and many others. It was remarked "just before the clock struck ten" by a sick man under Mr. Jones's care, as lasting about two seconds. There was no noise or repetition of the disturbance, and no damage has been complained of. The movement is said to have begun towards the north-west quarter.

FAYAL; 2° 57′ West of the Point of Observation at St. Michael's. Reported by Mr. Vice-Consul Minchin.

Point of Observation.—The chief town Horta, situated close to the sea on the east side of the island, from which there is a rise in a distance of about four miles to the base of a peak forming its crest, 3351 feet high.

Time and Phenomena.—The earthquake was felt while Mr. Minchin's clock was striking ten ($10^h\ 12^m$ at St. Michael's), lasting nearly three seconds, as observed by a clock a short distance from where Mr. Minchin was sitting. It was not accompanied by any noise; the direction of oscillation was not perceptible; it caused no damage, and was not felt on board the ships in the roads.

Summary of the foregoing particulars.

Place.	St. Michael's time.	Duration of disturbance.	Damage done.	Direction of vibration.	Subterraneous noise.	Effect atea.
	P.M.	seconds.				
St. Mary's ...	$10^h\ 8^m$	3	none.	S. to N.	slight.	?
St. Michael's .	10 3	6 or 7	considerable, greatest at the west end.	N.N.W. to S.S.E.	distinct.	strong on the west side.
Terceira	10 1	6 to 10	slight.	N. to S.	none.	slight.
Graciosa	10+?	2?	none.	S.E. to N.W.	none.	?
Fayal	10 12	3	none.	?	none.	none.
Flores	not	felt?				

Remarks.—In the foregoing particulars there is a general agreement that the vibrations of this earthquake were northerly and southerly. I feel great confidence in my own persuasion, formed at the moment, that the true direction where I was sitting was as I have stated it.

The time has been ascertained for St. Michael's, Terceira, and Fayal, but it is not known if the clocks were right. Supposing them

to be so, the disturbance was felt at Terceira before St. Michael's, and at the latter place before Fayal; and the progress of the movement was slower than would be expected.

To judge by the effects, the explosion would appear to have taken place at a short distance from the west end of St. Michael's; the force of the shock at Angra, at a distance of ninety miles from that end, having been the same as at Villa Franca, a town of St. Michael's, thirty miles in the opposite direction; and the greatest damage at St. Michael's having occurred in the north-western parts of this island.

I may add, without reference to any hypothetical reasoning, that the fall of rain in March was nearly three times the average of this usually rainy month, and that an average month's rain fell between the 17th and 21st of April.

British Consulate, St. Michael's,
June 30, 1852.

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2. *On the* Geology *of* South Africa. By G. A. Bain, Esq.

[Communicated by the President.]

[The publication of this paper is deferred.]

December 1, 1852.

John Moxon Clabon, Esq., James P. Fraser, Esq., The Rev. Osmond Fisher, Sir Charles Fellows, Professor Frederick M'Coy, and Edward Wood, Esq., were elected Fellows.

The following communications were read:—

1. *On* Pseudomorphous Crystals *of* Chloride *of* Sodium *in* Keuper Sandstone. By H. E. Strickland, Esq., F.R.S., F.G.S.

About one-third of a mile S.S.W. of the village of Blaisdon in Gloucestershire, I lately noticed in the side of a road some thin flaggy beds of the peculiar white sandstones, alternating with greenish marl, which have long been recognized in this country as the equivalents of the Keuper Sandstone of Germany. At this locality they are elevated at the unusually high angle of about 45°, dipping to the E. by S., a position which they doubtless owe to their proximity to the elevated Silurian mass of Blaisdon and Huntley Hills, distant only a few hundred yards on the W., and connected northwards with the May Hill range. For though the chief elevation of those Silurian rocks doubtless took place prior to the deposition of the Triassic series, yet there are abundant proofs along the E. flanks of the May Hill and Malvern ranges that additional upheavals were communicated to those masses subsequently to the Triassic period.

These beds of Keuper Sandstone thus elevated, are ripple-marked on their surface, and present the usual characters of the stratum as

it occurs in Gloucestershire. But what especially attracted my attention was that the surfaces, both upper and lower, of some of the sandstone beds, which alternate with laminæ of marl, are studded over with small bodies, resembling crystals, of cubical or nearly cubical forms. On examination, these apparent crystals prove not to be crystalline in their interior, but to be wholly composed of white sandstone, passing into, and inseparable from, the stratum from whose surfaces they project. It is also evident that the grains of sand which compose them are not held together by crystalline matter, like those in the well-known sandstone crystals of Fontainebleau, as they present no trace of cleavage planes, and their cubical forms prove them not to be due to carbonate of lime.

It appears then that these crystal-like bodies belong to the class termed pseudomorphous, and to the lowest subdivision of that class. In some cases, where one substance fills by chemical infiltration the cavity which has been formed by another, the product is still a crystalline body, though it has assumed an external form foreign to its real nature. But in the case before us the operation is purely mechanical;—the cavities formed by pre-existing crystals being merely filled with sand, poured into them from above, and taking the form of whatever cavities it might meet with.

The question next arises, what was the nature of the original crystals which are now replaced by sand? On examination we find that the majority of them are cubes or modifications of cubes. In some of them indeed a slight obliquity in their angles is perceptible, but this seems evidently owing to the effect of pressure, which has crushed and distorted the original form of the crystals, after they were replaced by the sand. We may therefore regard them as having originally conformed to the cubical type.

Of substances which crystallize in cubes, the only ones which usually occur in the Triassic formations are sulphuret of iron, or iron pyrites, and chloride of sodium or common salt. It is hardly possible that sulphuret of iron can have supplied the moulds into which the sand was afterwards poured, as it would require a considerable time both for the formation and for the removal of crystals of that mineral, whereas it is evident that the crystals in question must have been formed, and must have afterwards been removed, leaving an empty cavity, in the short interval between the deposition of one bed of sand, and of the one immediately superimposed. All these conditions, however, are supplied in the most satisfactory manner by supposing chloride of sodium to have been the material which formed the moulds for these pseudomorphous crystals. The ripple-marks,—the cracks formed by desiccation in the argillaceous beds, and afterwards filled with sand poured in from above,—and the not unfrequent impressions of the feet of air-breathing reptiles, all of which phænomena especially characterize the Keuper sandstones of our English counties, seem to point to a very shallow state of the sea, abounding with sand-banks, and extensive salt-water marshes, often laid bare in the intervals of the tides. If now we suppose that at the locality in question, a sandy marsh existed, which at high spring

tides was covered by the sea, we can easily conceive that in the interval between two spring tides, or in the still longer one between two æquinoctial tides, the sea-water, ponded up in such a marsh, had time to evaporate and to deposit its crystals of chloride of sodium, which being slowly and tranquilly formed would assume their normal shape of cubes. As the desiccation proceeded these crystals would be enveloped by the fine muddy sediment which usually forms the last deposit of water as it evaporates to dryness. When, after a given interval, the tide again overflowed the spot, the returning sea-water (not being saturated) would dissolve these saline crystals, leaving cubical cavities in the mud which contained them. The tide would bring with it a fresh deposit of fine sand, a portion of which would pour into the cavities formed by the crystals, and the remainder would form a homogeneous stratum immediately above. Such seems to me the probable explanation of the phænomenon in question, as seen on the *under* side of the slabs of sandstone. There are, however, examples on one of the slabs of similar crystals on the *upper* surface, similarly connected with the mass of sandstone, and less easy to be explained. In the former case we suppose the sand to have poured by simple gravitation into the subjacent cavity. But here the sand rises above its ordinary level, filling a cavity in the superincumbent stratum of marl. I can only suppose that here the crystals having formed between the sand and the mud which covered it, and being afterwards dissolved away by the returning tide, their places were filled by a portion of the subjacent sand, which being in a soft state, and intermixed with water, might without much difficulty be pressed upwards through the short space, not exceeding $\frac{1}{10}$th of an inch, in which these crystals project above the surface.

That chloride of sodium was the original substance that gave form to these bodies is further shown by the fact that in one example we find that peculiar concave figure so often seen in crystals of common salt, and which is due to the original cube floating at the surface of the brine, when a succession of smaller cubes form round its margin, and ultimately give it a kind of basket-shaped form, which is distinctly seen in the specimen in question.

These pseudomorphous crystals of salt therefore supply us with an additional evidence of those subaërial agencies affecting littoral deposits, of which the Keuper sandstone has already furnished examples in the ripplings, the rain-drops, the mud-cracks, and the reptilian footprints so often presented on its surface.

I may add, that on showing these specimens to Prof. J. Phillips, he informed me that he had seen similar examples of pseudomorphous crystals in the Keuper Sandstone at Spetchley in Worcestershire. There are also some specimens of the same phænomenon in the Museum of the Birmingham Philosophical Institution, presented by Miss Jukes, the locality of which I have not been able to ascertain. And Dr. Percy has kindly communicated a specimen from Clifton Grove, Nottinghamshire, which seems to prove the extension of Keuper Sandstone, affected by similar conditions, over a considerable

area in the Midland Counties. It is a greenish micaceous sandstone, closely resembling the Gloucestershire specimens,—ripple-marked on its upper surface, and covered below with cubic pseudomorphous crystals, the largest of which is about $\frac{1}{4}$ inch in diameter, and exhibits a trace of the basket- or hopper-shaped form, analogous to those above described.—[Jan. 21, 1853.]

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2. *On the* DISTRIBUTION *and* ORGANIC CONTENTS *of the* "LUDLOW BONE BED" *in the Districts of* WOOLHOPE *and* MAY HILL. By H. E. STRICKLAND, Esq., F.R.S. F.G.S. *With a Note on the Seed-like Bodies found in it.* By JOSEPH HOOKER, M.D., F.R.S. F.G.S. &c.

IN a paper read to this Society in June last* I noticed the occurrence at Hagley, four miles N.E. of Hereford, of that remarkable deposit the "Ludlow Bone Bed," a stratum interesting not only for its wide extension, as contrasted with its very slight vertical thickness, but also as presenting nearly, if not quite, the earliest known indication of Vertebrate Life on the surface of our Planet. I showed its close conformity, at Hagley, to the type of the same deposit as first described by Sir R. Murchison near Ludlow ('Silurian System,' p. 198), and enumerated certain Fish and Mollusca which it there contained. I also briefly referred to certain seed-like bodies which seemed to indicate the commencement, or at least the first appearance, of terrestrial vegetation.

The interest of the subject has since induced me to trace out the same deposit at various points towards the S.E. Prof. Phillips had already indicated the existence of Ichthyic fragments near the boundary-line of the Silurian and Devonian systems at two or three points in this direction (Mem. Geol. Surv. vol. ii. pp. 178, 191), but had not gone into much detail as to their structural character. Having succeeded in tracing this stratum at additional localities, and having obtained in it some fossil remains of considerable interest, it seemed desirable to communicate these results to the Society.

It will be remembered that at Hagley the Ludlow Bone-bed occurs as a thin stratum of fish bones, scales, and coprolites, mixed with carbonaceous fragments, not more than from one to two inches thick. The same bed occurs around the N.W. margin of the Woolhope district, between Stoke Edith and Prior's Frome, where vegetable fragments were noticed by Prof. Phillips, though the Bone-bed has not yet been there detected. At Prior's Frome Mr. Scobie has lately found specimens of the same seed-like body as that found at Hagley, which will be hereafter described.

At the locality now to be mentioned the bone-bed is much increased in thickness. This is at a point described by Prof. Phillips (*l.c.* p. 178) between Lyne Down and Gamage Ford, on the S.W. side of the Silurian area of Woolhope. The bed crops out in the side of a lane, and presents a stratum nearly a foot thick, containing the remains of Fish in immense profusion. Prof. Phillips describes

* See Quart. Journ. Geol. Soc. vol. viii. p. 381.

it as " a layer of fish-bones and pebbles in a loose blackened state," but though it is evidently a drifted deposit, I did not succeed in finding pebbles in it. It is literally a bone-bed, the great bulk of the deposit consisting of osseous and coprolitic matter, mingled with a very small proportion of sand and mud, barely enough to cement it together, and apparently containing no erratic fragments except a few marly nodules. Some portions of it have the appearance of a coarse brown sandstone, but on close examination it is found that the apparent grains of sand are really the so-called teeth of *Thelodus parvidens*, Agassiz (Silurian System, pl. 4. f. 34, 35, 36), which compose its entire substance. These curious little bodies, composed of two flattened pieces connected by a narrow neck, and which in form much resemble a common shirt-stud, are considered by Agassiz to be the teeth of a fish, though it appears to me not unlikely that they may be the placoid scales, and not the teeth, of the animal. It would be difficult otherwise to account for the extraordinary profusion of this minute organism, which forms by far the most abundant fossil of the Ludlow Bone-bed, wherever it occurs, and in this locality constitutes the principal bulk of the stratum.

The only other ichthyic fossils which I have noticed at this locality are the striated spines of *Onchus tenuistriatus*, Agassiz (Sil. Syst. pl. 4. f. 58).

Coprolites are abundant in the deposit. They are usually much rolled and water-worn, presenting but little regularity of form, though from their organic contents and the phosphate of lime which they contain*, there can be no doubt as to their nature.

The following Molluscous remains occur here, either imbedded in masses of coprolite, or in the form of casts filled with coprolitic matter :—

Orbicula rugata, Sow. Sil. Syst. pl. 4. f. 47, 48.
Lingula cornea, Sow. Sil. Syst. pl. 4. f. 49.
Turbo ?
Bellerophon expansus ?, Sow. Sil. Syst. pl. 4. f. 50.
Orthoceras semipartitum, Sow. Sil. Syst. pl. 4. f. 52, 53 ? Detached casts of chambers with the siphuncle *lateral*.

At Gamage Ford, as at Hagley †, rolled masses of carbonaceous matter accompany the animal remains. These are in the state of coal, and usually present no trace of their original structure. There are however some remarkable seed-like bodies evidently identical with those before noticed at Hagley and at Prior's Frome. They are usually of an almost perfectly spherical form, and present no trace of any point of attachment to the parent plant. Their diameter varies from 0·1 to 0·2 of an inch. The surface when in a perfect condition is very smooth.

On breaking open these globular bodies, a central cavity is seen, which is in some cases empty or filled with mineral matter ; in others it contains a powdery carbonaceous substance in which no organiza-

* See 'Silurian System,' p. 607, for the analysis of those in the Bone-bed at Ludlow.

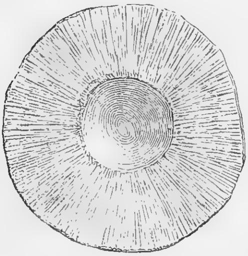
† *Loc. cit.* p. 382.

tion is perceptible. The diameter of this cavity varies from one-half to one-third of that of the entire body, so that the wall which encloses it is from one-fourth to one-third of that diameter in thickness. It is wholly composed of straight regular fibres, of even thickness, radiating from the internal cavity to the external surface (see fig. 1). The fibres have flat sides, and being closely packed together, they are necessarily, on the average, hexagonal. On rubbing down a portion of the external surface, the ends of these hexagonal fibres are exposed to view. They do not appear to be tubular.

In one specimen the extremities of these fibres are exhibited on the external surface by numerous small dark-coloured dots on a pale ground. Their outlines are here no longer hexagonal, but round or oval, often confluent, with a tendency to form parallel lines, yet subject to some irregularity (see figs. 2, 3)*. A further notice, by Dr. Hooker, of these curious fossils, and of a fragment of carbonized wood found with them, is appended to this paper.

Figs. 1, 2, & 3. *Showing the structure of the globular vegetable bodies found in the Ludlow Bone Bed.*

Fig. 1 *b*.



1 *a*.

Fig. 3.

Fig. 2.

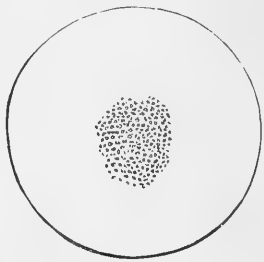


Fig. 1 *a*. Natural size.
Fig. 1 *b*. Transverse section; magnified.

Fig. 2. Dotted markings on the external surface; magnified.
Fig. 3. The same, more highly magnified.

In crossing the axis of the Woolhope elevation from Gamage Ford to Much Marcle, I again detected the Bone-bed, in the side of the road, near the base of the Old Red Sandstone. It here presents numerous rolled coprolitic fragments mixed with the supposed scales of *Thelodus parvidens*, imbedded in brown micaceous sand. I also noticed casts of an *Atrypa* in it.

The beds of yellow sandstone quarried at Gorstley Common, between Woolhope and May Hill, belong to the same part of the series as those which contain the Ludlow Bone-bed, though no remains of

* The object figured in Sil. Syst. pl. 4. figs. 65, 66, and described as the "palatal bone of *Sclerodus*," has every appearance of being one of these seed-like bodies split in half. Somewhat similar, though imperfect, specimens were found by Mr. Scobie and myself in the Cornstone of Llanfihangel, near Abergavenny.

Fish have yet been found in them. They contain however numerous vegetable remains, chiefly amorphous fragments of carbon in the state of coal. Among these frequently occur globular seed-like bodies identical with those above described, and exhibiting the same internal structure.

Proceeding six miles further S. nearly to the southern extremity of the May Hill elevation, there is an interesting section just laid open by the works of the Hereford, Ross, and Gloucester Railway at a place called the Velt-house. A cutting, of about 100 yards long, here exposes the lower beds of the Old Red Sandstone, the yellow sandstones termed "Downton Sandstones" by Sir R. Murchison (which are here about 20 feet thick), and a considerable extent of the Upper Ludlow Shales. The whole series is conformable, and dips about 75° to the W. Near the base of the Downton Sandstones, and 4 or 5 feet above the Ludlow shales, I detected the Bone-bed, not more than two inches thick, containing numerous rolled fragments of black coprolitic matter imbedded in a grey micaceous sandy shale. The scales of *Thelodus parvidens* are frequent, and I also found a spine of *Onchus Murchisoni**. The only other fossils noticed were casts of a depressed spiral shell, which appears to be the *Trochus helicites*, Sowerby, Sil. Syst. pl. 3. f. 1. *e*, but whose true generic position is doubtful. This shell has been also found in the Tilestones near Kington and in the Llandeilo district. Its resemblance to some of the commoner forms of recent *Helix*, such as *H. hispida* or *H. cantiana*, is very striking, though from its collocation it was probably a marine mollusc. The diameter is about $\frac{1}{2}$ an inch, the height $\frac{3}{8}$†.

I have thus traced this remarkable deposit of Ichthyic, Molluscous, and Vegetable remains from Hagley to the Velt-house, a distance of about seventeen miles. Prof. Phillips speaks of the equivalent of the Ludlow Bone-bed as occurring at Pyrton Passage, about seven miles further S. (Mem. Geol. Survey, vol. ii. part 1. p. 191). From this point to the banks of the Teme near Ludlow, where the Bone-bed was originally detected, is a direct distance of forty-five miles. It is not a little remarkable to find a stratum of such trifling thickness thus persistent in character through so wide an area. In this respect, no less than in the nature of its osseous and coprolitic drift, and in the fact that it occurs just at the boundary-line between two great geological systems, its analogies with the well-known Bone-bed at the base of the Lias are deserving of notice. In both cases we have indications of an extensive mortality among the Fish then in being, a phænomenon not improbably connected with the great physical changes which are proved to have taken place at the periods respectively indicated by these deposits.

* By *Onchus Murchisoni* I mean a genuine Ichthyodorulite, distinct from *O. tenuistriatus*, and agreeing with figs. 9 & 11 in plate 4 of the 'Silurian System,' but not with fig. 10, which Prof. M'Coy has shown to be a Crustacean. [Jan. 6, 1853.]

† The genus *Helix* does not, I believe, make its appearance until the Tertiary period; otherwise I should be disposed to speculate on the possibility of these Molluscs having been drifted down from the same land whence the seed-like fossils above described were probably derived. [Jan. 6, 1853.]

On the Sphæroidal Bodies, *resembling* Seeds, *from the* Ludlow Bone Bed. By Joseph Hooker, M.D., F.R.S. F.G.S.

The fossils in question consist of spherical bodies varying in size from 1 line to $\frac{1}{4}$ of an inch; they have suffered no compression nor mutilation during their conversion into mineral matter. The surface is nearly smooth and uniform to the naked eye, but seen under the microscope to be covered with circular or hexagonal areolæ, placed in contiguity in the latter case.

Fractured specimens show them to be hollow spheres, whose walls are fully twice as thick as the cavity they enclose. Their contents consist of a little loose white powder, of mineral matter, displaying no organic structure.

The walls (or integument) consist of a single series of narrow hexagonal cells, placed side by side, radially. The cell-walls are very thin, and exhibit no markings, nor are there any intercellular spaces. No vascular tissue is observed in any part, nor remains of any outer integument.

This simple structure of spore-case is very characteristic of the natural order *Lycopodiaceæ* and of the allied fossil genus *Lepidostrobus*, and I am not aware of any other order to which these fossils may more safely be referred. In their spherical form they differ from any known spore-case of this alliance, but mere form is a character of very minor importance in such organs, suggestive of specific only and not of generic difference.

In the great thickness of the walls and consequent length of the radiating cells forming the latter, they differ conspicuously from any recent or modern spore-case with which I am acquainted.

The great difference in size of the specimens, unaccompanied by any other character, is remarkable, as is the apparent absence of any point of attachment. The latter is probably due to contraction of the tissues, and cannot be regarded as any evidence of these fossils having been seeds or spores rather than the cases in which such are contained; for in some of the best specimens of *Lepidostrobus* which I have examined, there is no evident attachment between the spore-case and the modified leaf or scale which supports it, and through which it was nourished in its progress to maturity.

The accompanying fossil-wood presents very obscure traces of structure, and none on a cursory examination that throw any light upon the origin of the spherical bodies; but I have not had time to adopt the usual means for making a satisfactory examination.

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3. *On the* Supposed Fish Remains *figured on Plate* 4 *of the* 'Silurian System.' By Prof. F. M'Coy, F.G.S.

Having pointed out to Sir Roderick Murchison, about two years ago, the great resemblance which the so-called *Onchus Murchisoni* (fig. 10 of the above plate) bore to the slender didactyle pincers of a

Silurian Crustacean which I have figured in the first Fasciculus of the 'Cambridge Palæozoic Fossils,' Pl. 1. E. fig. 7, under the name *Pterygotus* (*Leptocheles*) *leptodactylus*, it occurred to him that examination might prove some of the other remains described by Prof. Agassiz as fishes in the 'Silurian System' to belong to the same class, and he accordingly sent me all the specimens, now accessible, figured on that plate, to examine and report upon. The specimens sent to me only belonged to the *Thelodus parvidens* and *Onchus tenuistriatus*, together with a fragment called on the plate "an Ichthyodorulite" (figs. 63 & 64), but I venture a few observations on all.

Figs. 1, 2, & 3, supposed to be shagreen of *Sphagodus*, I cannot determine without seeing the specimens.

Figs. 4 & 5; although these scale-shaped markings are stated to belong to a *fish* called *Pterygotus problematicus*, still M. Agassiz, in his volume on the Fishes of the Old Red Sandstone, very properly removes this genus from the class of Fishes and places it in its true class, *Crustacea*. I have suggested, in the work on the Cambridge Fossils, that *Pterygotus* belonged, not to the Macrurous Crustacea, but to the group *Pœcilopoda*, allied to the recent *Limulus* or King-crab, and recent discoveries published in this Journal confirm this opinion*: the supposed fish-tooth (fig. 6) called *Sphagodus pristodontus* would in this case, almost certainly, be not a fish (to no known tooth of which has it any accurate analogy), but the masticating, serrated edge of the basal joint of one of the feet surrounding the mouth of the same *Pterygotus*, the sculpturing of whose carapace is represented by figs. 4 & 5.

The genus *Pterygotus* is divisible into two subgenera: 1. *Pterygotus* proper, in which the didactyle claws are very thick and armed with powerful teeth; 2. *Leptocheles* (M'Coy), in which the pincers are very slender and unarmed. As before mentioned, figs. 9, 10, & 11, representing the so-called *Onchus Murchisoni*, Ag., are almost identical in form, size, sculpturing, and all other characters (as far as they are represented in these drawings), with the distinctly didactyle pincers which I have figured (Brit. Pal. Foss. pl. E. fig. 7) from Leintwardine, under the name *Lept. leptodactylus*, in which the two fingers occur, *in situ*, removing all doubt as to its true nature. If this approximation prove correct, the fossil should in future be called *Leptocheles Murchisoni* (Ag. sp.); and I might add, that the number and relative position of the fragments on the stone figured, instead of being singular, as supposed, would thus be nearly natural. I might further remark, that the drawing shows no attenuation at the base of these supposed fish remains, nor any of the other distinguishing characters of Ichthyodorulites. As this specimen unfortunately cannot now be referred to, great importance attaches to the fragment (fig. 64) called simply "an Ichthyodorulite" on the plate, the right-hand extremity of which so exactly coincides with the sup-

* See Mr. Salter's observations on *Pterygotus*, Quart. Journ. Geol. Soc. vol. viii. p. 387.

posed *Onchus Murchisoni* in diameter, sculpturing, and number of ridges, that it is exceedingly probable they are the same. Now this specimen I have examined, and have no hesitation in stating decisively that *it is not an Ichthyodorulite,* and that it is one of the fingers of the claw of a *Leptocheles*; for in the first place, the base, instead of being abruptly attenuated like the dorsal ray of a fish, is dilated, *and both it and the longitudinally grooved portion are merely the internal cast of a hollow, fragile, cretaceous crust, only equalling the lower dark outline of the drawing (or stout paper) in thickness,* as in the legs of ordinary Crustacea. These two characters are decisive against the fossil being a fish-defence.—Fig. 63, called an "*Onchus,*" is on the same stone with the last specimen, and from the analogy of the second pincers which I have figured as above of *Leptocheles leptodactylus,* I have no doubt it is the last or moveable joint of a smaller pair of claws of the same *Leptocheles Murchisoni,* for the analogy pointed out between the *Pterygoti* and the *Limuli* prepares us to expect *several pairs* of didactyle pincers of different sizes and proportions *in the one individual.*

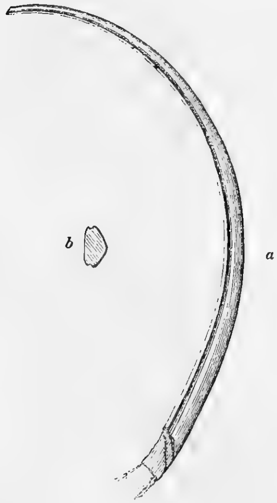
I have mentioned that the typical *Pterygotus* had the claws armed with strong teeth, as in the common lobster; this is well seen in Agassiz' figure of the pincers of the *Pterygotus Anglicus* of the Old Red Sandstone, and to the genus as thus restricted I have no doubt the supposed fish teeth and jaws belong, figured under the numbers 14, 15, 16, 17, 18 to 32, and 60, 61, 62, under the names *Plectrodus mirabilis, P. pliopristis,* and *Sclerodus pustuliferus.* Why separate generic names should have been given to fragments so identical as *Plectrodus mirabilis* (figs. 15 & 16) and *Sclerodus pustuliferus* (fig. 62), I cannot divine. As one of these specific names expresses a character distinguishing this *Pterygotus* from the large one of the Scotch Old Red Sandstone, it should have the preference, and these fossils might stand in future lists as *Pterygotus pustuliferus* (Ag. sp.) = *Plectrodus mirabilis* + *P. pliopristis* + *Sclerodus pustuliferus,* Ag. Any reflecting comparative anatomist looking at fig. 14, will agree, I think, in the opinion that no known fish-tooth, recent or fossil, has the slightest structural analogy to warrant comparison with it for a moment; and on the other hand, the most casual observer can trace identity with the tooth-like tuberculation on the claws of the common lobster.

Having disposed of the spurious fish-remains, I may state that the *Onchus tenuistriatus* (figs. 12, 13, 57, 58, 59) is an *undoubted Ichthyodorulite.* Not only all the external characters indicate this, but on submitting a transparent section of one of the fragments scattered through the rock to a high magnifying power (with the kind aid of Mr. Carter), I am able to state positively the existence of the Purkinjian bodies and true microscopic structure of bone therein. This example of a Silurian Fish is, therefore, perfectly correct; and it only remains to add, that all the specimens of the Downton Castle rock which I have examined, impress me strongly with the conviction that the last name on the list, the *Thelodus parvidens,* should be considered not as that of a fish-tooth, but of granules of the skin or

shagreen of the same fish, in all probability, of which fragments of the bony dorsal rays (*Onchus tenuistriatus*) are so common intermingled in the same mass. M. Agassiz, judging only from the drawing (figs. 34, 35, 36), supposed these magnified and isolated specimens to resemble teeth of the general character of *Lepidotus*; but one glance at the specimens would dissipate this notion, when we find that they are square and not rounded, that they are as small as grains of fine sand, and occur in such abundance over large patches of rock as to resemble thick layers of sand. All these points speak against their being teeth, but are in accordance with the supposition of their being the earthy grains or shagreen of the skin of large cartilaginous fishes; and, finally, having made an examination of transparent sections in a powerful microscope, I found, instead of the close dentine of the teeth of *Lepidotus*, only the loose divaricating tubular structure usually found in such dermal armature as has no grinding duty to perform.

Postscript.—The specimens forwarded to me, from the Collection of the Geological Society, as supposed *Ichthyodorulites* from the Wenlock limestone of Whitfield, Tortworth, are the nacreous, shelly tubes of a new species of *Serpulites*, which I name *S. perversus* from the singular character of the general curve of the fossil being in a plane at right angles to that in which the tube is compressed. The average length is 3 inches, and width $2\frac{1}{2}$ lines at the large end.

Serpulites perversus (M'Coy), from Whitfield Quarry, near Tortworth, Gloucestershire. Collected by T. Weaver, Esq., F.G.S.



a. Side view of a large specimen; natural size.
b. Section at the thickest end.

4. *On some of the* Remains *in the* Bone-bed *of the* Upper Ludlow Rock. By Sir Roderick I. Murchison, F.R.S. G.S. &c.

In looking over the Woodwardian Museum of the University of Cambridge last year, I perceived that Professor M'Coy had, among his many skilful arrangements, discovered that a fossil from the Lower Ludlow rock, which if detached I should have called an ichthyodorulite, was one finger of the claw of a large crustacean analogous to the *Pterygotus* of Agassiz; an animal which, though at first classed with fishes, was long ago removed by that author himself into the order of Crustacea.

In this case indeed there could be no mistake, for in the specimen, which Professor M'Coy had then named *Pterygotus leptodactylus*, one solid finger was seen to be closely attached at its base to an unequivocal cast of the other, thus representing the claw of a small lobster.

Now although this body was taken, as above stated, from the Lower Ludlow rock, it appeared to be very desirable that Professor M'Coy should closely scrutinize some of the remains of the bone-bed of the Upper Ludlow which had been referred by Agassiz to fishes. For, as the great ichthyologist had formed his opinion from the drawings only which I sent to him, and had never had an opportunity of looking into the framework of those fossils with the microscope, it seemed not unlikely that some of them might also prove to be crustaceans.

I accordingly procured for the examination of Professor M'Coy the specimens from the museum of the Geological Society which I had originally placed there, and others from the cabinet of my friend the Rev. T. T. Lewis. I regret to say that some of the most curious of the fragments published in the 'Silurian System,' which were found by the late Rev. R. W. Evans and beautifully arranged on cards by that gentleman, are nowhere to be found. In respect to such forms the naturalist can therefore only refer to the etchings of Mr. James Sowerby and Mr. Salter; and those I can testify (Mr. Lonsdale being also a living witness) were most minutely accurate and faithful representations of the originals.

Professor M'Coy has been led to think that the *Onchus tenuistriatus* (Sil. Syst.) is the only true fish-defence of the Upper Ludlow rocks, the other fish-remains, *Sphagodus* and *Thelodus* (Ag.), being recognized as the osseous particles of the shagreen or prickly skins of shark-like fishes. The *Plectrodus* and *Sclerodus* (Ag.) as well as the *Onchus Murchisoni*, are removed by him to Crustacea.

On consulting Mr. Salter, who has communicated with Mr. Sowerby, I find that they cannot adopt this view. They necessarily bow to the discovery made by Professor M'Coy, that three of the fragments, figs. 10, 63, and 64, in plate 4 of the 'Silurian System,' which were grouped with the *Onchus Murchisoni*, are really crustacean, and have the thin hollow crust characteristic of that class; but they hold decisively to the opinion, that the figures 9 and 11 of the *Onchus Murchisoni* represent true fish-bones; Mr. Salter, who drew these two specimens himself, having a distinct recollection of their thick solid

structure. Mr. Sowerby, who etched the jaws of the *Plectrodus* and *Sclerodus*, has also no doubt, that, although they may pertain to one genus, they are unquestionably fish jaws, as shown by fractures of the solid bone which are represented in the figure (see fig. 61). *Sclerodus pustuliferus* (figs. 60, 61, 62) was drawn by Mr. Salter, who reminds me of the cancellous structure of its broken end, and which he distinctly recollects to have been quite unlike the shelly crust of the *Pterygotus*. It is but justice, however, to Professor M'Coy to say, that he does not consider the existence of this solid and cancellous texture a sufficient reason to induce him to change his present opinion.

Whilst, therefore, the discovery of Professor M'Coy has shown us that one or more of the supposed fragments of fishes are really crustacean, we may, it seems, continue in the belief that the greater part of the remains are those of fishes. Let us hope that, as this bone-bed has recently been found to re-appear from beneath the Old Red Sandstone near Hereford, and has been traced by Mr. Strickland to the southern extremity of the May Hill district, and even in 1848 was found by Professor Phillips at Pyrton Passage on the Severn, we may be supplied with fresh specimens to replace the originals figured in the 'Silurian System,' and that by subjecting them to the microscope we may for ever terminate all doubt.

Again, as Professor M'Coy shows that there are remains of a shark-like fish in this deposit, we may still consider the small, smooth, elongated, and convoluted bodies, which were analysed by Dr. Prout, to be the true coprolites of fishes.

As the author of the Silurian System, I hope to be excused if I remind my associates that the most assiduous researches in various regions where the earlier groups of fossils have been widely spread have failed in detecting anywhere a zone of higher antiquity than the Upper Ludlow, in which the remains of fishes are imbedded. Thus these venerable small ichthyolites are still, what I announced them to be long ago, the most ancient known beings of their class*. These few traces of fishes being detectable only at the close of the first long æra of primæval life, it follows that the Silurian deposits as a whole are prominently separated from all those which succeeded, by the invertebrate character of their very numerous fossil animals, among which the cephalopods that so abound probably performed the duties of the fishes and were the scavengers of the pristine seas. In all succeeding systems and formations the remains of fishes are, as is well known, found in association with other marine spoils.

Having heard that Mr. Lewis of Aymestry had discovered an ichthyodorulite in the Wenlock limestone, I procured the specimen, which, being referred to Mr. Salter, was instantly identified as the *Ptilodictya lanceolata* (Lonsdale), a coral published in the 'Silurian System.'

* Sil. Syst. p. 606.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

REVIEW *of the* CLASSIFICATION *of the* PALÆOZOIC FORMATIONS *adopted by* M. DUMONT *for the* GEOLOGICAL MAP *of* BELGIUM, *with Reference to its Applicability to this Country.* By DANIEL SHARPE, Esq., F.R.S., G.S.

Read JUNE 16, 1852.

[For the other Communications read at this Evening Meeting, see vol. viii. p. 381.]

THE division of the palæozoic series adopted by M. Dumont for the beautiful Geological Map of Belgium, which he has just completed by order of the Belgian Government, must necessarily produce a change in many of the views of English geologists; since he has now worked out, by the strict evidence of superposition, the order of the formations lying between the old unfossiliferous slates of the Ardennes and the Carboniferous series, while the unconnected position of those formations in England has prevented us from ascertaining their relative ages with certainty. Having had the advantage, in company with several of our colleagues, of discussing with M. Dumont the value of his divisions and of inspecting the fossils collected from them, I hasten to bring the matter to the notice of the Society, that the valuable results of M. Dumont's labours may be made known and applied here.

The following extract from M. Dumont's "Tableau des Terrains de la Belgique" contains the description of the older stratified rocks,

from the Coal-measures down to the unfossiliferous slates of the Ardennes:—

Terrain anthraxifère.	Système houillier		Ampelite, psammite, schiste, houille.
	Système condrusien	Calcareux	Calcaire à crinoïdes, dolomie et calcaire à productus, silex, anthracite.
		Quartzo-schisteux	Psammite grisâtre, macigno, anthracite. Schiste grisâtre, calcschiste, calcaire, oligiste oolitique.
	Système eifelien	Calcareux	Calcaire et dolomie.
		Quartzo-schisteux	Schiste gris fossilifère, calc-schiste, et calcaire argilleux, oligiste oolitique. Poudingue, psammite et schiste rouge.
Terrain Rhénan.	Système ahrien		Grès, psammites et schistes gris-bleuâtres.
	Système coblentzien		Grès et phyllades gris-bleuâtres.
	Système gedinnien		Poudingues, grès verts et phyllades rouges-verts ou aimantifères.

Terrain ardennais.

In the above table there are two important alterations of the views published by M. Dumont in 1830 in the well-known Memoir on the Province of Liège, which have an important bearing on our English classification. In the memoir of 1830 the *Système quartzo-schisteux inférieur*, following next below the limestone since identified with that of the Eifel and of South Devonshire, was divided into an upper division of red sandstone with conglomerate, and a lower division of argillaceous schists; thus bringing the Red Sandstone formation immediately below the Eifel limestone. M. Dumont now recognizes a great series of fossiliferous schists lying conformably below the Eifel limestone, and resting, often unconformably, on the red sandstones. M. Dumont explained the omission in 1830 of the Schistose series to have arisen from his observations being then confined to the province of Liège, in which they are but little seen; as soon as he extended his inquiries westward into Hainault, and eastward towards the Rhine, the importance of the schistose series became manifest, and led to its separate insertion in its proper place.

The other change is of detail, and consists in dividing the lower member of the *Système quartzo-schisteux inférieur*, which lies below the Red Sandstone series, into three divisions—the *Systèmes ahrien, coblentzien et gedinnien*, which are grouped together as the *Terrain Rhénan**.

The first of these alterations brings the South Devon series into

* It must be observed that M. Dumont now uses the word *Terrain* in the sense in which *System* is often used in England, while his term *Système* is applied to a *division* only of the *Terrain*: the terms, being purely conventional, are equally applicable in either sense, but it is unfortunate that they should have received such different applications from different authors.

exact parallelism with that of Belgium, as we now see in each country a great series of fossiliferous schistose beds surmounted by, and intimately connected with, a calcareous series, viz. the limestones and subjacent schists of South Devon, and the Eifelian limestone and schists of Belgium and the Rhenish provinces; and the above series is thus disconnected from the Red Sandstone formation. It now becomes quite unnecessary to force the Old Red Sandstone of England into a parallelism with the schists and limestones of South Devon, as was done in 1837 by Mr. Lonsdale, Professor Sedgwick, and Sir R. I. Murchison. And our Old Red Sandstone appears on a parallel with the Belgian formation of red sandstone and conglomerate, the *Poudingue, psammite et schiste rouge* of M. Dumont, as was suggested in 1829 by M. Rozet. And instead of having, as in 1830, only two formations represented as intervening between the Eifel limestone and the slate-rocks of the Ardennes, M. Dumont now presents five well-established groups of rocks in that interval.

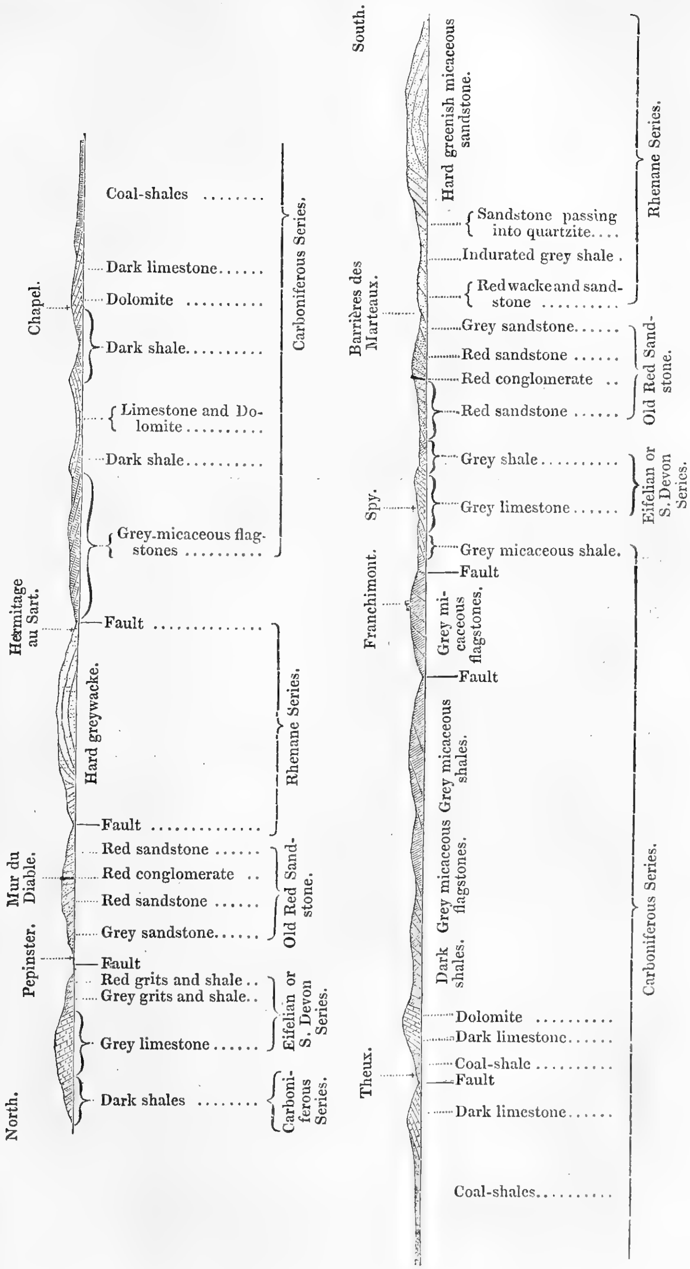
Our short visit to Belgium did not give us time to verify all the new divisions, but M. Dumont's accuracy as a field-geologist is too well known to render such confirmation necessary. I had, however, the advantage of examining, in company with Mr. Austen, one of the most illustrative lines of section along the valley of the Hoegne and Wayay, from Pepinster by Spy to the Barrière des Marteaux, and we drew up together the annexed section, fig. 1, which we submitted to M. Dumont on our return to Liège. We were glad to find that it coincided with the lines laid down on his map, and with his present views of the relative position of the masses of rock.

The section thus represented differs materially both from that given by Professor Sedgwick and Sir R. I. Murchison in the sixth volume of our 'Transactions,' second series, pl. 23. fig. 12, and also from the more theoretical section A. B. of M. Dumont's first memoir. At that time M. Dumont endeavoured to explain the complicated structure of the province of Liège by flexures and folds of the rocks without any break in the continuity of the beds. Such flexures undoubtedly exist in that district in a remarkable degree, but there are also many faults accompanied with great upward shifts, by which beds of very different age are brought to the same level: thus, at Pepinster the Eifelian schists meet the red sandstones; a little south of Pepinster, the red sandstones abut against the Rhenane greywackes; farther south, near the Hermitage du Sart, the last-named rock meets the Carboniferous series. None of these circumstances can be explained by the mere bending of the rocks, as the beds which are in contact belong in each case to different formations. From Theux to Les Marteaux the beds lie in a regular order, and the correct sequence of superposition may be traced without any difficulty, thus correcting the erroneous impression which might have been formed from the dip of the younger towards the older rocks in the northern parts of the section.

The northern end of our section shows one of those inversions of the strata which attracted so much attention when they were first described by M. Dumont. The Eifel limestone, dipping S. 15°

Fig. 1.—*Section from Pepinster towards Spa.*

(Distance 6 miles.)



W. 60°, leans over the lower carboniferous shales. A little to the north of this spot, the limestone and shale are seen in their natural position, but, as their strike differs considerably from that at Pepinster, they could not be shown in the same section. The accurate working out of a country in which such disturbances are of common occurrence has placed M. Dumont's name in the first rank of European geologists.

The difficulty of arranging the rocks of Devon and Cornwall seems mainly due to the existence of faults of the same character as those above described, accompanied with flexures similar to those of the Belgian coal-field. In those counties masses of rock of different ages are brought into contact along east and west lines of fault; and the prevalence of a southerly dip gives them an appearance of conformable superposition, which has led to most erroneous and contradictory views of the relative ages of the different masses on the part of different observers.

Let us now compare the divisions of M. Dumont's Table with our English formations. The *Système houillier* answers to the *Coal-measures* of our midland counties, and to the *Upper Coal Series* of Northumberland and Scotland.

The *Système condrusien* corresponds to our *Carboniferous Series*;—the upper calcareous division, including the Visé limestone, crowded with large *Producti*, &c., may be compared to the limestone of Matlock and Bristol. The middle division of grey psammite with some beds of anthracite answers to the arenaceous series between our Upper and Lower Carboniferous limestones, on which level coal is worked both in the north of England and in Scotland. The lowest division, of grey and carbonaceous shales, dark limestones and iron-ore, is best matched in Northumberland and in the Lothians. We saw the upper part of this division in the great quarries round Tournay, where the following beds are laid open:—

Alternations of dark shale, containing *Spirifer*, *Cyathophyllum mitratum*, &c., with clay-iron-stone.

Dark limestone.

Black shales, alternating with some thin beds of limestone; the shales full of corals and small shells, among which *Pleurotomariæ* are especially abundant.

The lower limestone shales of Northumberland and of the Scotch coal-fields contain an assemblage of shells much resembling those of Tournay, and I am disposed to place in the same division the whole of the Culm-series of Devonshire, together with the underlying fossiliferous beds of Pilton and Barnstaple (and perhaps Marwood) in North Devon, and of Tintagel and South Petherwin in the South, the organic contents of which agree much more nearly with Carboniferous, than with Devonian species. In 1843 I urged Mr. Morris to separate this group in his Catalogue from the Devonian system *, and the opinion of many palæontologists has gradually come round to the same view.

The *Système eifelien* of M. Dumont is formed of three distinct

* See Catalogue of British Fossils, 1843, Introduction, page x, Note.

groups,—the Eifel limestone, Eifel fossiliferous schists, and the red sandstones and conglomerates. The synchronism of the limestones of South Devon and of the Eifel is now universally admitted. Each of these limestone-groups is underlaid by a great formation of shale and schist, occasionally fossiliferous, showing a complete accordance of this part of the series in the two countries.

The lowest division, or *Poudingue, psammite et schiste rouge*, presents exactly the mineral characters of the upper portion of our *Old Red Sandstone*: where we saw it at Pepinster it consists of the following beds:—

Red sandstone.

Coarse red conglomerate, about 20 feet thick, made up of large and small pebbles of quartz, jasper, Lydian stone, slate, &c.

Red sandstone.

Grey sandstone.

The most remarkable bed is the conglomerate, which is quite vertical at Pepinster, and crosses the hills in a ridge 20 or 30 feet high, resembling an ancient fortification, from which it has obtained the name of the *Mur du Diable*. The beds dip at high angles and the thickness of the series is considerable. M. Rozet estimated it at 150 metres or about 500 feet, which cannot include all the series; and although this may appear trifling when it is compared to the enormous development of the Old Red Sandstone in Shropshire and Herefordshire, it is probably greater than the thickness of that formation in Westmoreland. In 1829 M. Rozet published a paper in the 'Annales des Sciences Naturelles' (vol. xix. p. 113) in which he distinctly asserts that the Belgian red sandstone, seen between Dinant and Namur (the continuation of the Pepinster bed), is the equivalent of the English Old Red Sandstone, in which view he was afterwards supported by M. C. Prevost*. In this identification I entirely coincide. We thus separate the Old Red Sandstone from the schists and limestones of South Devon, and regard it as a lower independent member of the series; and thus we are relieved from the necessity of supposing that in the same sea two deposits were forming at a short distance apart, the one of red sandstone and conglomerate, the other consisting of grey schists and limestones, without there being any interchange of characters between them, or any gradual passage from one to the other. We might admit two such different deposits to have been formed at the same time in different seas, but between the Old Red Sandstone of South Wales and the schists of Devonshire there is no trace of any axis of older rock which could have divided the ocean at the time these deposits were being formed.

There appears to be no limestone in the Old Red Sandstone series of Belgium, nor have organic remains been found in it; this will not prevent our identifying it with the Old Red Sandstone of this country, large districts of which have neither afforded any limestone nor any such organic remains.

* Bull. Soc. Géol. de France, vol. ix. p. 82, Dec. 1837. The same view was taken in 1850 by M. Delanoue, Bull. Soc. Géol. de France, 2nd series, vol. vii. p. 366.

The *Terrain Rhénan* of M. Dumont comprises three divisions, of which the lowest or *Système gedinnien* appears to belong to the top of the Silurian system. The two upper divisions, called *Ahrien* and *Coblentzien*, which are consequently intermediate between the Old Red Sandstone and the Silurian system, have not yet been recognized in England: the few species of organic remains found in them connect them with the Eifel series, since they all differ from those of the *Système gedinnien* below, while nearly half are found in the Eifel series above the Old Red Sandstone *: the most characteristic and abundant species seem to be *Spirifer ostiolatus, S. macropterus*, and *Pleurodictyum problematicum.*

The uppermost division, or *Système ahrien*, is described as consisting principally of "*grès, psammites et schistes gris-bleuâtres*:" where we saw it on the line of our section, we found the following descending series:—

Grey grits, with divisions of grey shale.
Red grits, schist, and wacké.
Indurated greenish-grey shale.
Sandstone passing into quartz-rock.

The upper and middle portions of the "Ahrian system" resemble the grey schistose and sandstone series of Ilfracombe and the Valley of Rocks, resting on the harder red sandstone series of Linton and the Foreland, in which *Spirifer ostiolatus* is the prevailing shell. With these we must also connect the rocks between the limestone of Plymouth and the mica-schists of Bolt Head †, consisting of grey, chloritic, schistose, and arenaceous beds, of great thickness, overlying red sandstones, which last are stated by the authors quoted to bear the closest resemblance to the red arenaceous rocks east of Combe Martin ‡: the red sandstone south of Plymouth is said to overlie the Plymouth limestone, in which statement there must be an error, as it leads to inextricable confusion in our classification of the rocks, from which we can escape by supposing that the Plymouth limestone, being the younger rock, dips towards the older sandstones south of it; these, having also a dip southward, appear to overlie the limestone, from which they must really be separated by a great fault running east and west.

Système coblentzien, comprising *Grès et phyllades gris-bleuâtres.*—Our excursion did not extend to the rocks of this series. The organic remains found in it are more numerous than those in the "ahrian system" above it. In M. Dumont's collection we observed several large Devonian species of *Spirifer*, and also several large species of *Orthis* and *Leptæna*, yet unknown in this country. No part of Devonshire can be referred to this division, but perhaps the *Système coblentzien* may be found in the south of Cornwall, where large districts still belong to the "terra incognita" of geology.

* Lists of the species will be found in M. Dumont's Mémoire sur les Terrains Ardennais et Rhénan, p. 227; and his collection contains others not included in those lists.

† Sedgwick and Murchison on Devonshire, Geol. Trans. 2nd series, vol. v. p. 657, and pl. 51, fig. 5.

‡ *Loc. cit.* p. 657 and p. 663.

The *Système gedinnien* is the lowest division of M. Dumont's *Terrain Rhénan,* and the lowest fossiliferous rock found in Belgium. This division must be separated from the Devonian series, with which M. Dumont's classification connects it, since it does not contain a single species found in the "coblenzian" or "ahrian" divisions above it. On the other hand we observed in M. Dumont's collection from this division so many forms with which we were familiar in the Upper Silurian beds, that Prof. E. Forbes and myself referred it with little doubt to the Tile-stone division of the Upper Ludlow rock. It rests, according to M. Dumont, unconformably on the unfossiliferous slate series of the *Terrain Ardennais,* which forms the great axis of the Ardennes.

The minor divisions adopted by M. Dumont all appear consistent with nature; but the larger groups must be modified, to bring them into harmony with the great divisions now established on the ground of containing the same organic remains.

The *Terrain anthraxifère* should surely begin at the *Système condrusien* or Carboniferous Series, which is well distinguished by its fauna from the "Eifel system" below it: but the continuance throughout of a number of fossil species connects together the *Systèmes eifelien, ahrien,* and *coblentzien,* which, taken together, constitute all that ought to be included in the "Devonian system," from which, as stated before, the Barnstaple and South Petherwin beds must be removed.

The red sandstones are not naturally the base of the Eifel series, but rather the top of the Rhenane series, being formed at the end of a long period, in which the sea was becoming shallower, and the deposits both more arenaceous and more ferruginous; both of which characters were gradually increasing during the Rhenane period, after which the true Eifel series commences with grey shales deposited apparently in deep water.

The "Gedinnian system" must be entirely separated from the Rhenane series, with which, as already stated, it has no organic remains in common, and should stand alone as the sole representative in Belgium of the Silurian system*.

The Table of Belgian formations, thus modified, will compare as follows with our English strata.

In the following scheme, an entire separation is established between the Old Red Sandstone and the true South Devon or Eifel series of limestones and schists, but it may admit a doubt whether the lower members of the Old Red Sandstone series of South Wales may not have been synchronous with the Ilfracombe and Linton

* The principles which have led M. Dumont to adopt his present arrangement of greater groups, or *Terrains,* will be found in an article "Sur la valeur du caractère paléontologique en Géologie," in the Bulletin de l'Académie Royale de Belgique, tom. xiv. No. 4. Every great deposit of conglomerate is considered to have been the result of a period of physical disturbance, which broke the series of deposits and caused the destruction of previously existing animals. The remains of these animals will be found among the transported materials forming the first beds of the new formation, therefore "*les divisions paléontologiques ne peuvent concorder exactement avec les divisions géologiques fondées sur les révolutions du globe.*"

Belgian Formations.		*Equivalents in England.*	
Système houiller		Coal-measures.	Carboniferous series.
Système condrusien	Limestone with *Productus*, &c.	Upper Carboniferous Limestone.	
	Sandstones with anthracite	Carboniferous Sandstone of Derbyshire, Shap Fell, &c.	
	Limestone and shale	Lower Carboniferous Limestone. Lower Limestone-shale of Northumberland and Scotland, and Culm-measures of Devonshire, including Petherwin and Pilton beds.	
Système eifelien	Limestone of the Eifel	South Devon Limestones.	Devonian series.
	Schists, occasionally calcareous, &c.	Shales and schists below ditto.	
	Red sandstones and conglomerates	Old Red Sandstone.	Old Red or Rhenane series.
Système ahrien	Grey and red psammites and schists, &c.	Ilfracombe and Linton series; Sandstones and schists south of Plymouth.	
Système coblentzien	Grey schistose grit, &c.	To be sought for in the south of Cornwall.	
Système gedinnien	Red and grey sandstones, &c.	Tile-stones of Upper Ludlow series.	Silurian.
Terrain ardennais	Unfossiliferous slates	Oldest Slates of Wales and of the south of Scotland.	Cambrian ?

deposits. In that case we must assume the upper member of conglomerate and sandstone to be either wanting in Devonshire, or concealed below the Culm-measures, and the Ilfracombe group to represent the middle or marly division of the Old Red, and the Linton red sandstones its lower division. The occurrence of the Upper Silurian Tile-stones immediately beneath the Old Red Sandstone, throughout the greater part of its course, favours this view, and there is nothing in the mineral character of the North Devon rocks inconsistent with it. But it will be premature to attempt to decide the question until we know more of the older rocks of South Wales, and can ascertain whether there are in that district any "Rhenane" beds below, and independent of, the Old Red Sandstone.

The sandstone with *Cucullææ* which occurs at Marwood in North Devon, and has not been observed elsewhere, has no representative in South Devon nor in Belgium; it is doubtful whether this rock should be regarded as a member of the Rhenane or of the Carboniferous series.

It is worthy of remark, that in the State of New York there is a great series of beds characterized by Devonian fossils, below what is considered to be the Old Red Sandstone*. These will now stand on the parallel of the "Rhenane" group of Belgium.

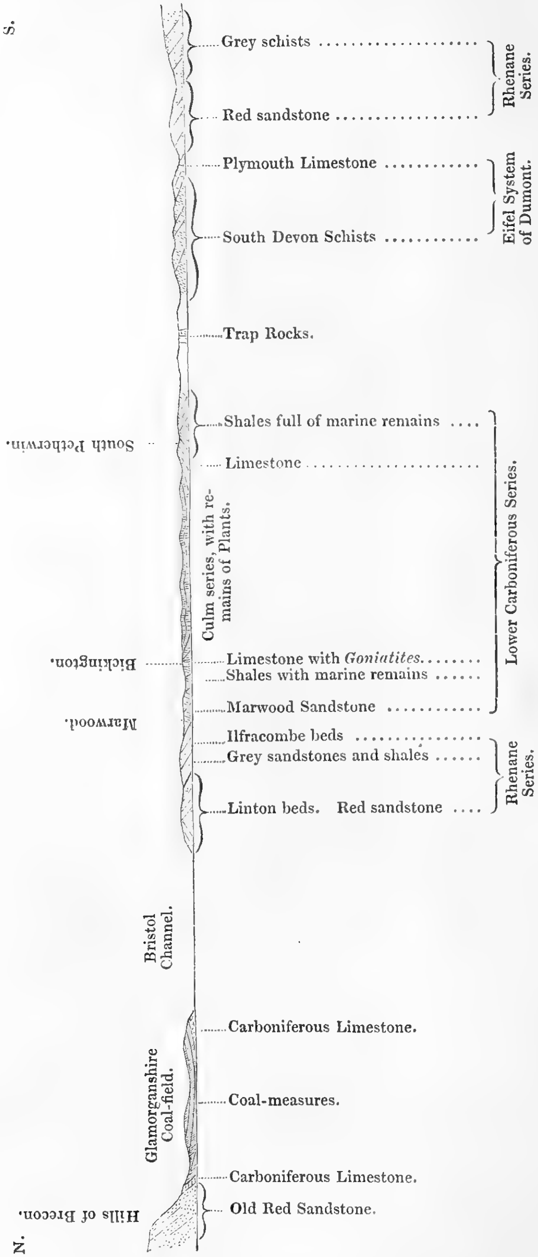
The section, fig. 2, from the Old Red Sandstone of Brecon to the south of Devonshire, shows the relations of the different rocks upon the scheme advocated in this paper. Their position offers several anomalies;—on the north we have the Old Red Sandstone of South Wales dipping towards the Linton beds, which are supposed to be older deposits. On the south of the Culm-basin, the fossiliferous beds of S. Petherwin have not yet been well separated from the older deposit of schists and limestones of South Devon, and a similar difficulty occurs again where the Plymouth limestone dips south towards an older group of "Rhenane" rocks. Yet these faults are not more violent than those which M. Dumont has proved to exist in formations of similar ages in Belgium. And when the two sections, figs. 1 and 2, are compared, it will be found that the faults are so nearly counterparts in the two districts, as to suggest the idea that they are really continuous.

Liège and Launceston stand nearly on the same parallel of latitude, and in both districts the general direction of the faults approaches east and west. In both districts we can trace an enormous movement prior to the Carboniferous period, which produced great east and west faults, and, by unequal elevation of the masses, brought rocks of very different ages into contact on a common level: thus, the "Rhenane" rocks, both of Linton and of the Hermitage du Sart, form an arched ridge between younger deposits, and reappear to the south less disturbed. These ridges of the older rocks stood above the water in both districts, and the carboniferous beds were deposited in the troughs between them. Somewhat later we find proofs of another great movement along nearly the same lines, by which the

* Sharpe on the Palæozoic rocks of N. America, Quart. Journ. Geol. Soc. vol. iv. p. 156. De Verneuil, Bull. Soc. Géol. Fr. 2 Ser. vol. iv. p. 646.

Fig. 2.—*Section from the Old Red Sandstone of Brecon to the South of Devonshire.*

(Distance about 120 miles.)



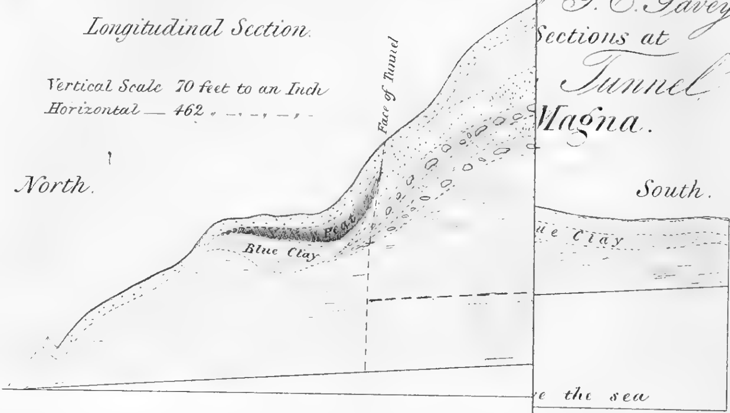
…uttings,
…SHIRE.
…Mr G. E. Gavey's
…Sections at
… Tunnel
…Magna.

FIG. I.

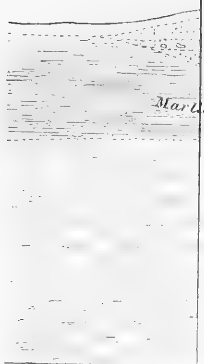
Mickleton Tunnel.
Longitudinal Section.

Vertical Scale 70 feet to an Inch
Horizontal — 462 " — " — " — "

North. South.



West.



…e, 70 feet to an Inch.
140 " " " "

FIG. II.

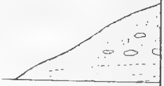
Mickleton Tunnel.
Transverse Section.
at A, Fig. 1.

No…

FIG. III.

Section at Aston Magna,
near Moreton-in-Marsh.

…le, 35 feet to an Inch.
.140 " " " "



G. E. Gavey. del. C. Achilles lith.

whole of the carboniferous rocks were disturbed and partially elevated, with the remarkable peculiarity that the southern parts of both districts have been squeezed up into parallel folds, from which the northern parts are comparatively free. Thus the Culm-field of Devonshire and the southern side of the Belgian coal-districts are bent in parallel folds, while the coal-field of Glamorgan and the northern portion of the Belgian coal-fields are much less disturbed. The disturbing forces are thus shown to have operated along a line on the south of the two districts under consideration; and on one end of that line we have the elevation of the Ardennes, and on the other the mica-schist of the Start Point and Bolt Head, the gneiss of the Eddystone, and the serpentine of the Lizard Point. The line of elevation runs on the south side of the Devonian and carboniferous rocks of the Boulonnais, which form a connecting link between the disturbed districts of Belgium and Devonshire here referred to.

I cannot conclude without acknowledging with thanks the assistance which I have received from Mr. R. A. C. Austen, both during our excursion in Belgium and the drawing up of this review.

On the Railway Cuttings *at the* Mickleton Tunnel *and at* Aston Magna, Gloucestershire. By G. E. Gavey, Esq., C.E., F.G.S.

[Plate I.]

These sections occur on the Oxford, Worcester, and Wolverhampton Railway. Mickleton Tunnel is situated near the north-eastern extremity of the Cotteswold Hills. It passes through them in a north and south direction, near the village of Mickleton; the north end opening out into the Vale of Evesham, and the southern into the Vale of Moreton-in-the-Marsh.

The Tunnel, which is about half a mile in length, has been driven through the upper beds of the Lower Lias Shale; and during its excavation, but more especially in the cuttings at each end of it, numerous rare and beautiful fossils were discovered.

The surface of the ground on the summit of the Tunnel is 490 feet above the sea; it is on a level with the Marlstone of the hills to the east and west, and is composed of loamy siliceous gravel, sand*, and red clays to a depth of 76 feet, disposed in layers resting immediately upon the upper beds of the Lower Lias Shale (see Pl. I. figs. 1 & 2).

The following is the order of the beds from above downwards:—

		feet.	in.		feet.	in.
Vegetable soil	about				0	9
Loamy sand and pebbles	from	5	0	to	15	0
Fine loamy sand passing into coarse sand	,,	5	6	,,	20	0
Gravel and clay	,,	5	0	,,	30	0
Red clay with boulders of Marlstone	,,	2	0	,,	6	0
Loose shingly gravel	,,	1	0	,,	16	0
Red clay with boulders of Marlstone	,,	2	0	,,	15	0
Lower Lias Shale	more than				80	0

* This siliceous sand contained about 30 per cent. of fine oolitic sand.

Railway Cuttings, GLOUCESTERSHIRE.

To illustrate Mr G. E. Gavey's Paper on the Sections at Mickleton Tunnel & Aston Magna.

FIG. I.

Mickleton Tunnel. Longitudinal Section.

Vertical Scale 70 feet to an Inch
Horizontal — 462 " " " "

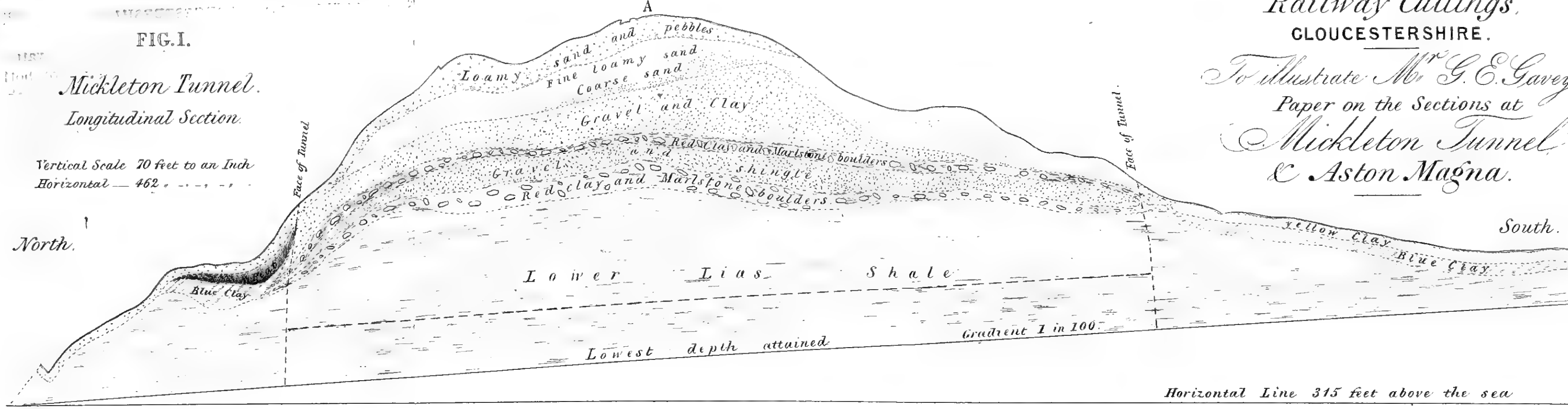


FIG. II.

Mickleton Tunnel. Transverse Section at A, Fig. 1.

Vertical Scale 70 feet to an Inch.
Horizontal — 140 " " " "

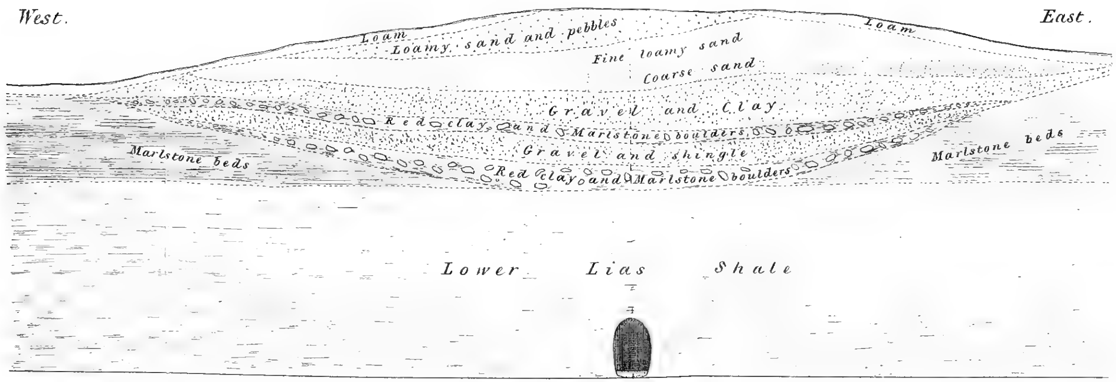
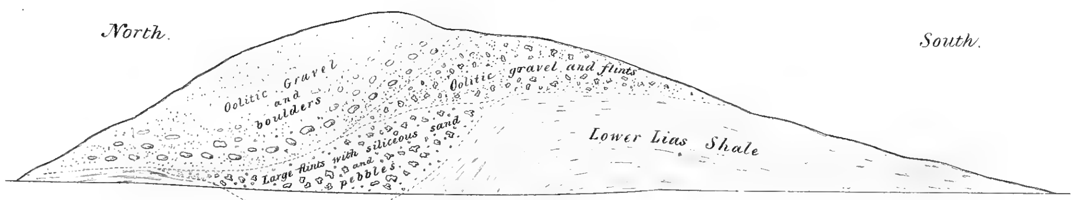


FIG. III.

Section at Aston Magna, near Moreton-in-Marsh.

Vertical Scale 35 feet to an Inch.
Horizontal 140 " " "



G. E. Gavey del. C. Achilles lith. F. Reeve imp.

The sands and gravels are limited to about 170 yards on either side of the Tunnel, and have an anticlinal arrangement, the beds dipping irregularly north and south. In one instance the gravel dips 15° to the west.

In the sand and gravel beds there were found but very few shells, which were principally *Gryphææ*, and a few *Belemnites*; but in the lowest gravel-bed the fossils were more numerous, consisting chiefly of *Ammonites, Belemnites, Gryphææ, Serpulæ*, &c., all bearing the appearance of being much water-worn. This bed is composed of fine and loose gravel, like shingle; and there is but very little sand with it*.

The beds of red clay† are non-fossiliferous, but contain large detached blocks of Marlstone, of a bluish colour and of uneven fracture, and with the edges very much rounded by attrition. On their surface I found various impressions and casts of shells; the most numerous was the *Cardium truncatum*; there were also *Pecten, Trochus, Leda, Ammonites planicostatus*, &c. On breaking up the blocks, many of them exhibited the remains of Fucoids.

The gravel, sand, and clay seem to have formed the bed of a channel communicating between the Moreton and Evesham Valleys, having Dover's and Campden Hills to the west, and Ebrington Hill to the east.

The upper beds of the Lower Lias Shale‡ lie immediately underneath the lowest bed of red clay, the Marlstone-beds having been entirely removed in this place by denudation; the only remains of the latter are the detached blocks, before-mentioned, lying in the beds of red clay.

The shale was sufficiently hard in some cases to require blasting, but generally speaking it was easily removed, being very wet§ and full of joints, and requiring the greatest care in working. When brought to the surface and exposed to the air, the shale soon mouldered into a bluish clay, which was found serviceable for making the bricks used in casing the Tunnel.

The fossils found in excavating the Tunnel were, with some few exceptions, in a very imperfect state of preservation, and great care was requisite to prevent their falling to pieces. On some of the *Arcæ*, and one or two other shells, when first excavated, I perceived concentric bands of a brownish colour, which disappeared on exposure to the air. Many of the blocks of shale were covered with two or three

* Great difficulty was experienced in sinking through the thick beds of running sand, on account of the immense quantity of water they contained. Straw was used to keep the sand from running out with the water while the miners were fixing the timber; the straw has since become incrusted with the carbonate of lime, forming a solid mass between the planking and the sand-bed.

† The tenacity of the red clay is such, that when a small part of the Tunnel gave way, and the shale, being unsupported, fell in in a few hours, leaving a superficial area of red clay 12 feet square, the clay retained its position for three days, supporting the superincumbent gravel and sand; after which time however it broke, causing an immediate settlement on the surface.

‡ There was not a trace of the Upper Lias beds met with during the excavation.

§ Intermittent springs occurred in the shale.

species of *Ostrea* with both valves preserved, but generally in a crushed state; there were also a considerable number of *Belemnites* (*B. ovalis* and another species). Many of them were much corroded, as though they had been lying for some time at the bottom of the sea; whilst others showed every appearance of having been buried alive in the deposit.

Layers and rounded concretions of ironstone were found at various depths, but not in continuous beds; they were also of different thicknesses—from two to twelve inches, and from one to a few feet in length and width. Their surface was generally covered with very interesting and well-preserved fossils. The stone has not been assayed, but is supposed to contain a large per-centage of iron; it is very hard, with a conchoidal fracture. The colour is a light brown when excavated, but on exposure the stone oxidizes to a dark brownish red*.

In the shale I found numerous spherical nodules of an impure limestone or indurated shale, varying from one to eight or nine inches in length, with the outer surface soft, but becoming very hard towards the centre. When broken open they disclosed a hard black substance; this, upon examination, was found to have been a crustacean, which had formed the nucleus; the extremities of the animal were not unfrequently well preserved in the exterior and softer part of the stone, but not so the body, for, so rarely is the true form of the crustacean distinguished in these nodules, that out of several hundreds that I have broken I have met with but four or five specimens in which the outline of the body can be fairly traced. These nodules do not affect a regular stratification, but lie promiscuously throughout the shale, and resemble in colour and hardness those of the London Clay.

There are other nodules in the shale, but they are comparatively rare and have more the appearance of Coprolites. These are not so hard, and do not, as far as I ascertained, enclose any fossil remains.

Only a few detached bones of Saurians have been found; viz. a spinous process and a few vertebræ of the *Plesiosaurus*.

No beds of limestone were met with, and the shale was generally of the same description throughout, somewhat arenaceous and occasionally laminated; it became much harder and heavier on sinking through it to a depth of 90 feet, which would be 164 feet from the surface at the highest point. The beds are nearly horizontal, dipping slightly to the north, at an angle of one degree; they do not seem to have been much disturbed, although the shale is much disintegrated†.

In the open cutting at the north end of the Tunnel, beneath the loamy clay and gravel that forms the surface-drift, a small deposit of

* Much ironstone occurs in the top beds of the Lower Lias in several other parts of Gloucestershire. It was formerly worked at Robinswood-Hill near Gloucester, and contains a large per-centage of metal. The beds at Mickleton are particularly rich. [Note by the Rev. P. B. Brodie.]

† It required to be expeditiously worked, for otherwise, if left and exposed to the air for three or four days, the superincumbent earth being supported only by timber preparatory to the brickwork being put in, the shale would begin to swell and break the timber, thereby endangering the work.

peat was cut through. See Pl. I. Section, fig. 1. The peat was sandy in the upper part, and from 3 to 7 feet thick. It contained bones of *Bos* (short-horned), *Equus*, *Cervus* (two species), *Sus*, and *Canis vulpes*; and in a layer of dark sandy earth and pebbles (6 inches thick) at the base of the peat were found Hazel-nuts, shells of *Helix*, *Planorbis albus*, and *Pisidium*, and the elytra of a *Carabus*. Beneath the peat was a bed of blue clay, 3 to 8 feet in thickness and penetrated by roots, in which, at 9 feet 6 inches from the surface, a human skeleton* was found, indicating a comparatively recent date for this deposit. The extent of the peat and clay is very limited as shown in the section, and seems to have been accumulated in a small natural pond which had become drained in later times.

The Lower Lias Shale lies immediately under the above-mentioned blue clay, and in this cutting is not very fossiliferous, as compared with that of the Tunnel and south cutting. It contains similar indurated nodules and slabs of ironstone, on which innumerable fragments and columns of *Pentacrinus* were found, but no perfect specimen was discovered. A few *Ammonites* and a very limited number of shells, generally of a different species to those elsewhere met with, and mostly in a crushed state, were also collected. The shale is much impregnated with iron-pyrites.

In the cutting at the south end of the Tunnel the two beds of red clay and the lower bed of gravel (as shown in the longitudinal section, fig. 1) crop out at the tunnel-mouth immediately underneath the vegetable mould, and are at this place very much contorted. The gravel contains the same fossils as before mentioned, all much water-worn.

In the red clay large marlstone-boulders were imbedded, very much rounded by attrition and similar to those before mentioned; they were from one cwt. to 3 tons weight each, splitting up sometimes into rough slabs, and containing in their interior many perfect shells, resembling those found in the Lower Lias Shale of this cutting.

The yellow clay which lies immediately under the vegetable mould along this cutting is much mixed up with the gravel at the tunnel-mouth for a few yards, after which it forms a regular bed of stiff yellow clay, about 5 feet thick, passing at that depth into a tenacious blue clay†, which rests on the Lower Lias Shale. In one or two localities I perceived a thin layer of quartz-pebbles between the blue clay and the shale.

The upper beds of shale in this cutting are light-coloured, arenaceous, and sometimes of a laminated structure; they contain but few fossils, and assume a yellowish colour when exposed to the air.

* The skeleton lay in a slanting position, the head elevated, and the face turned upwards. I am indebted to C. G. Blatchley, Esq., C.E., for the above information.

† A stump of a tree, about 9 inches in diameter, was found erect in the blue clay, at about 7 feet below the surface; it was in a very decomposed state, and was not carbonized, but seemingly impregnated with iron-pyrites.

Underneath this bed, and at 14 feet below the surface, there is a thin bed of ironstone, of a dark brown colour and of a rough uneven fracture, differing from any hitherto met with; it forms a continuous layer of rounded and irregular nodular masses for about 400 feet, and is from 6 to 8 inches thick. Some rare fossils were found in it, viz. *Lingula Beanii, Orbicula,* large spines of a *Cidaris,* and a few other fossils.

The shale underneath this ironstone-bed becomes of a darker colour and considerably harder and heavier the deeper the excavation is proceeded with.

It is seldom that these beds are laid open to such an extent and depth as shown in the section, Pl. I. fig. 1. Their inclination, as at the other end of the Tunnel, is towards the north at an angle of one degree*. From the immense number of Cephalopods (chiefly *Ammonites planicostatus* and *Belemnites ovalis*) which have been found in this cutting, the shales appear to have been deposited in deep water. They are more arenaceous in some parts of this cutting than in others, forming thin slabs of a fine bluish sandstone, on which many of the *Echinodermata* were found. There were also large slabs of ironstone, of the same description as those found in the Tunnel, but much more fossiliferous, many of them being almost entirely composed of shells, &c. These slabs of ironstone were very numerous, and many of them 16 inches thick. Their upper and under surfaces in many instances were covered with innumerable fragments of *Pentacrini,* together with many fine specimens of Starfish†.

The *Uraster Gaveyi*‡, E. Forbes, was discovered lying on the upper surface of a slab of sandstone, 12 inches thick, at 25 feet below the surface, associated with fragments of *Pentacrinites, Ammonites,* and other fossils.

All the specimens of *Tropidaster pectinatus*§ and *Cidaris Edwardsii* were found attached to the under side of a thick slab of ironstone at about 20 feet below the surface. Almost all the specimens show the ventral surface, and most of them had the spines attached to the spiniferous plates; the *Cidaris,* when first found, was entirely covered with spines, so much so as to conceal the interambulacral plates.

The Oyster-beds were very interesting, for I found them *in situ* at different depths; they were limited in extent, and the shells were generally in a crushed state and varied in size from ½ an inch to 3½ inches in diameter. There were traces of Plants, and large fragments of carbonized wood. One piece was about 7 feet long, and more than 1 foot wide, but, being in a crushed state, it was only 1½ inch thick; it was converted into jet. Other pieces were of a dark brown colour, impregnated with iron-pyrites.

* The beds of shale were generally undisturbed throughout the cutting; but I remarked that in one part, for the distance of forty yards, they were much distorted, and had a waved appearance; the ironstone was here lying in various positions and the fossils were ground to pieces.

† A new species of *Ophioderma* was found on one of them.

‡ Mem. Geological Survey, Decade III. plate 2.

§ Mem. Geological Survey, Decade III. plate 3.

List of the Fossils found in the Mickleton Tunnel and Cuttings.

PLANTÆ.

Fossil wood and traces of Plants.

ECHINODERMATA*.

Cidaris Edwardsii †, *Wright.*
Ophioderma Gaveyi, *Wright.*
—— Milleri, *Phill.*
—— ; another species.
Pedina, n.sp.; allied to *P. rotata*, Agas.
Pentacrinus tuberculatus, *Miller.*
—— ; 2 new species.
Tropidaster pectinatus, *E. Forbes.*
Uraster Gaveyi, *E. Forbes.*

CONCHIFERA.

Arca Buckmani, *Richardson.*
—— truncata, *Buckman.*
——; new species.
Astarte; 3 new species.
Avicula inæquivalvis, *Sow.*
—— longi-axis, *Buckman.*
Cardium truncatum, *Sow.*
—— ; 2 new species.
Cypricardia?
Gervillia lævis, *Buckman.*
—— ; another species.
Goniomya; 2 species.
Gresslya unionides, *Goldf. sp.*
——; 3 new species.
Gryphæa incurva, *Sow.*
—— Maccullochii, *Sow.*
Hippopodium?
Inoceramus dubius, *Sow.*
—— ; new species.
Leda pinnata, *Bean, MS.*
—— rostralis, *Lamk. sp.*
Limea; 2 new species.
Lingula Beanii, *Phill.*
Modiola scalprum, *Sow.*
—— ; 2 new species.
Nucula; with cast of the intestinal canal present in most of the specimens.
Orbicula.
Ostrea; 2 new species.
Pecten corneus, *Sow.*
—— ; new species.
Pholadomya ambigua, *Sow.*
—— ; new species,
Plicatula spinosa, *Sow.*
Rhynchonella rimosa, *Buch, sp.*
—— ; new species.
Terebratula.

GASTEROPODA.

Chemnitzia; new species.
Cylindrites; new species.
Dentalium giganteum, *Phill.*
Rotella polita, *Bronn.*
Trochus imbricatus, *Sow.*
—— ; 3 new species.

CEPHALOPODA.

Ammonites annulatus, *Sow.*
—— Cheltensis, *Murch.* (=*A. Henleyi*, Sow.)
—— planicostatus, *Sow.*
Ammonites; a species allied to *A. Davœi*, Sow.
—— ; 3 other species.
Belemnites; 2 species.
Nautilus.

ANNELIDA.

Serpula; 2 species.

CIRRIPEDIA.

Pollicipes; 2 new species.

* The top beds of the Lower Lias at Hewlett's Hill, near Cheltenham, contain a minute *Cidaris* (in clusters) with attached spines, also a small species of *Ophiura*. [Note by the Rev. P. B. Brodie.]

† The new species of Echinoderms in this list have been described by Dr. Wright in a paper read before the Members of the Cotteswold Naturalists' Club, which paper will shortly appear in the 'Annals of Natural History.'—[T. W.]

Crustacea.

Three species. Two are new forms belonging to the family *Astacidæ*; and the other is a new species allied to the genus *Æga**.

About four miles S.S.E. from Mickleton Tunnel is another cutting of some interest, through a low ridge branching off from the Cotteswolds at the village of Aston Magna.

The cutting in question lies north and south, which gives a transverse section of the hill. See Pl. I. section, fig. 3. From the north end to the centre of the cutting the upper bed consists of a thick accumulation of gravel, sand, and clay, derived from the Inferior Oolite. This is not disposed in layers, but forms an unstratified deposit, capping the summit of the hill, and containing large blocks of the same formation lying in various positions. From the centre of the cutting this deposit becomes mixed with a large quantity of small chalk-flints, which are common in the neighbourhood. It may therefore be inferred that this accumulation of oolitic gravel, &c., consisted of the debris of the Cotteswold Hills during their denudation, but which had not been long subjected to the action of water, for the gravel and blocks of oolite bear no appearance of having been rolled, and differ very much in this respect from the large deposits of rolled oolitic gravel near the village of Paxford, about two miles distant from this point; neither had the few fossils (chiefly *Terebratulæ*) which I found any appearance of being waterworn.

In the centre of the cutting, and lying immediately under the above-mentioned oolitic gravel, &c., is a thick deposit of very large chalk-flints, many of them weighing one and two cwt. each. They are not waterworn, and retain their original white coating uninjured.

These are intermixed with blocks of hard Chalk, Greensand, and clay, together with a quantity of siliceous sand and pebbles†. The greatest thickness of this bed is about 17 feet; it is 200 feet long, thinning out north and south.

I collected a few *Terebratulæ* from the blocks of Greensand, but

* Mr. Salter remarks on this fossil, "I have compared it, with Mr. Adam White's help, with *Cymothoa* and its allies. The genus *Æga*, a near ally of *Cymothoa*, presents the most resemblance to the fossil in the shape of the rings and the strong impressed line which traverses them. But your specimen has the eight anterior rings preserved, and the sixth and seventh are nearly of the same width, a character which makes it more like a *Cirolæna*: *C. hirtipes* is the species which has been compared with yours. Both *Æga* and *Cirolæna* occur in Britain, and both are parasitic upon fish. The fossil is a very good specimen. The anterior ring, just behind the head, is notched for the reception of that part, but it is unfortunate that the sides are not more cleared, as they would probably show a granulated surface. Though I have mentioned *Cirolæna* as being its near ally, it is more probably a distinct genus either from that or *Æga*, for in both these genera there is a sudden change in the form and size of the segments, at the sixth in *Æga*, at the seventh in *Cirolæna*. Now, your specimen has no decided change; the seventh and eighth are only a little narrower than the preceding ones. If I were to refer it to any existing genus, I should say *Æga*, the general surface and habit being very nearly like that genus."

† This debris of flint and greensand seems to indicate an extension of the Chalk and Greensand beds at a former period above the Oolite of this district.—[Note by Rev. P. B. Brodie.]

they were very imperfect. The Chalk fossils consisted mostly of *Ventriculites*, with one or two other forms.

These detrital deposits rest on a bed of Lower Lias Clay about 7 feet thick, very rich in fossils, which are small and very perfect. The Lower Lias Shale lies underneath this blue clay, and is also very rich in fossils. These beds are much distorted, forming a hollow, in the centre of the cutting, in which the large flints, &c., are deposited. They dip to the east, but the inclination is not uniform, varying from one to fifteen degrees. The shale differs very much in this cutting from any hitherto met with in this neighbourhood; it is of a dark-blue colour, and the fossils found in it are quite different from those found in the shale of the other cuttings, a few hundred yards north and south of it. The characteristic fossil is the *Spirifer Walcotti*, which is not met with elsewhere in any other cutting along this Railway, although it is frequently found near Gloucester.

A cutting about 250 yards north of the Aston cutting is composed entirely of the upper beds of the Lower Lias Shale, with a covering of sand and clay, containing a few erratic boulders of Marlstone, but there is not the least appearance of oolitic gravel or flints. The shale is very arenaceous and resembles that of the cuttings at Mickleton, but is not nearly so fossiliferous. In a cutting on the south side of this hill, near the village of Dorn, the first 360 yards are composed of the upper beds of the Lower Lias Shale, containing fossils quite distinct from those of Aston cutting, also ironstone similar to that found at Mickleton (north cutting); the rest of this cutting from Dorn to Moreton is composed of siliceous sand and pebbles, together with a loamy clay mixed with small flints, which forms the substratum. So that the Aston cutting differs materially from the cuttings to the north and south of it.

List of the Fossils from the Shale of Aston Cutting.

ZOOPHYTA.

Caryophyllia; 2 species.

CONCHIFERA.

Arca; new species.
Astarte; 3 new species.
Gervillia lævis, *Buckman.*
Gresslya donaciformis, *Phill. sp.*
Gryphæa; 2 species.
Leda rostralis, *Lamk. sp.*
—— pinnata, *Bean, MS.*
Limea; new species.
Nucula ovum, *Sow.*
Nucula; 2 new species.
Pecten textilis, *Münst.*
Plicatula spinosa, *Sow.*
Rhynchonella; 2 new species.
Spirifer Walcotti, *Sow.*
Terebratula numismalis, *Lamk.*
—— punctata, *Sow.*
——; new species.

GASTEROPODA.

Chemnitzia; 3 new species.
Cylindrites; new species.
Pleurotomaria anglica, *Sow. sp.*
Rotella polita?, *Bronn.*
Trochus imbricatus, *Sow.*

Cephalopoda.

Ammonites armatus, *Sow.*
—— ; 2 new species.
Belemnites ; 2 species.

Annelida.

Serpula ; 2 species.

Crustacea.

Fragments.

I beg to express my sincere thanks to the Rev. P. B. Brodie, H. E. Strickland, Esq., and Dr. Wright, for the kind assistance they have afforded me in naming the fossils, as well as for other information.

On Foot-tracks *found in the* New Red Sandstone *at* Lymm, Cheshire. By Robert Rawlinson, Esq., Civil Engineer.

[Communicated by the Right Hon. the Earl of Ellesmere, F.G.S.]
(Read June 16, 1852*.)

The quarries from which these footsteps were obtained are opened in an elevated ridge of land near Lymm, half-way between the towns of Altringham and Warrington, on the south side of the Bridgewater Canal, and about one mile distant from it†. The ridge runs nearly due east and west, and is about 200 feet above the level of the sea. This ridge and a parallel one on the north of the same elevation form the boundary of the valley of the Rivers Mersey and Irwell, and by skirting this valley the Bridgewater Canal obtains its level, crossing both rivers by aqueducts at Barton and at Stretford.

The quarries now worked are three in number, lying in a line nearly due east and west, and are opened at intervals of about half a mile from each other. They are worked to a depth of about 23 feet, and the following is the order of stratification in all, from above downwards:—

	Feet.	
Soil, from 9 inches to	1	
Red marly shale	5	
Light blue and yellow shale	9	
Red rock, in parallel beds, varying from 3 to 12 inches in thickness	8	The footsteps are found in these beds only.
	23	

* For the other papers read at this evening's meeting, see Quart. Journ. Geol. Soc. vol. viii. p. 381 *et seq.*

† A cast of a slab with foot-prints now at Worsley Hall has been presented to the Society by the Earl of Ellesmere. Prof. Owen has examined the slab, and reports that there are four prints of the hind-feet of the *Cheirotherium Kaupii*, and that the fore-foot has been so lightly impressed that the ball of the foot only has left its mark, without the toes touching or sinking in the bed. The hind prints, he adds, are unusually well and regularly impressed.—[J. C. M. Sec. G.S.]

Many of the beds of rock are more or less ripple-marked, but it is on two or three of the lower beds only that any of the foot-tracks have been found. The line of the stratification is very even and uniform, with a southerly dip of one in twelve. The foot-tracks are generally either up or down the slope, although, at times, the track is in a diagonal direction; some are faint, whilst others are more deeply indented. The ripple-marks present every variety of form that may at present be met with on a modern sandy beach. There is the continuous, nearly straight, and nearly parallel ridge; there is the short, dappled, pitted condition; and there is also the smooth surface. The directions of the ripple-marks are not all one way in the various beds overlying each other; but they have been changed in their direction, probably with a change of current or of wind. In a thickness of less than an inch there may be seen two sets of ripple-markings at right angles to each other, plainly showing a corresponding difference in the causes which produced them.

Where the foot-prints are preserved, there is always, in the divisions of the beds of rock, a bed of clay, varying from one to twelve inches in thickness. Some of the thicker beds of clay also exhibit sun-cracks. The clay has evidently been held in suspension by the tidal waters, and has been deposited over the sandy beach betwixt high and low water; the animals have walked over the yielding shore, to and from the water, leaving the prints of their feet on the clay, and the sun has dried the freshly-formed mud. With the beach in such a state as described, the next deposit has been sand, which, either held in suspension in water, or drifted by the wind, has been quietly deposited over the impressions, and the next and succeeding tides brought sand, and laid it out over the beach, until the next local change again caused a deposit of clay or mud; thus dividing the beds of rock into strata of various thicknesses, as now exhibited in the quarries.

There are several ways to account for this alternation in the stratification. The ancient beach we are contemplating may have bounded a tidal river, or an estuary, or the ocean; but most probably an estuary having clay or marl strata within the reach of spring-tides, floods, or storms, and extensive sand-banks within its waters. Violent action would saturate the waters with mud, as land-floods and spring-tides in the River Mersey are now saturated; whilst a calm and steady current over sand-banks would carry only the finer and lighter portions of the suspended material which would be deposited over the beach. Thus like causes would produce like effects, and the ocean of that distant date doubtlessly rolled as freely, and the sun shone as brightly and warmly as now. Of this we are certain, that there were earth, water, air, and heat; and that there also were animals, apparently of strange and uncouth forms. Traces of vegetables in these deposits are not common, and such as are found are generally detached fragments lying horizontally, the hollow stems filled with the material of the surrounding rock; the solid portions of the plants are carbonized, and the whole are compressed in the line

of the stratification: I am not aware that any bones, teeth, spines, scales, or other osseous or enamelled parts of animals have yet been found.

The beach-line existing at the time that the footsteps were imprinted may be hypothetically laid down as extending from beyond Altringham on the east, to Leasowes Castle on the west, with a slight curve to the southward. It is indicated by the occurrence of foot-prints and ripple-marks at the Lymm, Runcorn, and Storton quarries, which lie about 10 miles apart along this line. From Altringham to Lymm and Runcorn the supposed beach-line trends somewhat to the S.W., and comes within 3 miles N. of Frodsham. It then curves upwards to the N.W., and at Storton is about $2\frac{1}{2}$ miles S.W. of Liverpool. At Runcorn and at Storton the rock is several hundred feet thick, and is divided into many beds of varying thicknesses; the foot-impressions are confined to a few of these beds only, yet all of them appear to have had the requisite materials for preserving such markings; namely, clay betwixt the beds of sand-rock. The side of the rock upon which the raised casts of the impressions are found is always downward, and upon clay, so that they are casts in sandstone taken from clay upon which the impressions were indented by the animal when in motion.

It may be asked, how it is that foot-impressions are not found on the whole of the beds in the same quarry? The following are a few reasons which may be brought forward in answer to this question:—

1st. The stratification is so marked as to bear all the evidence of having been a tidal beach, probably a portion of an estuary to some great river, barred by extensive sand-banks, and subjected to land-floods surcharging the waters with mud. Hence the alternations of arenaceous strata and thin clay-beds, as now found. If such has been the case, it may be put thus:—As the beach-line is to the river, estuary, ocean, or the whole extent of the stratified rock, so will be the rarity of places producing specimens; a chance of many hundreds to one against any given quarry, opened indiscriminately, revealing specimens.

2ndly. For the full formation of the impressions several conditions were requisite, and all must have been fulfilled at the same time. The beach, usually of sand, must by some local change have been coated with mud. That change, probably wrought by a storm or land-flood, must have been succeeded by a calm, or the impressions would have been erased by the next tide.

3rdly. To account for the impressions occurring at intervals, it must be remembered that animals usually locate in groups, and do not spread indiscriminately.

These reasons may partially account for these or similar impressions not appearing more frequently even in the same locality or the same quarry. From the impressions being accompanied by suncracks in the clay, it must have been the summer season; and the same heat that could crack the clay or mud would also partially harden it, thereby giving it a consistency to resist the wearing

and wasting influence of the next flowing sand-bearing tide, which quietly deposited a portion of its burden over the mud-coated beach; and this quiet action must have been continuous for some time, or the moveable shore would have been easily deprived of every distinctive trace. Thus there must have been a tidal beach-line, with clay or mud strata, to be wasted by high tides or local storms; and neighbouring sand-banks to form an extensive sandy beach during low tides and quiet weather.

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I. TRANSACTIONS AND JOURNALS.

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American Journal of Science and Arts. Vol. xiv. nos. 40, 41. *From Prof. Dr. Silliman.*

———— Philosophical Society, Proceedings. Vol. v. no. 47.

Asiatic Society of Bengal, Journal. Nos. 225–228.

Assurance Magazine. Nos. 8 & 9. *From the Institute of Actuaries.*

Athenæum Journal, June, July, August, September, October.

Berlin Academy of Sciences. Transactions, 1850.

————. Bulletin from July 1851 to June 1852.

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THE

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OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

December 15, 1852.

Frederick William Smith Packman, Esq., M.D., and James Arthur Morgan, Esq., were elected Fellows.

The following communication was read:—

On Changes *of the* Sea Level *effected by* existing Physical Causes *during* Stated Periods *of* Time. By A. Tylor, Esq., F.G.S.

(Withdrawn by permission of the Council.)

[Abstract.]

In this communication, the author first calculated the probable amount of the solid matter annually brought into the ocean by rivers and other agents, in suspension and solution, and the conclusion arrived at is, that the quantity of detritus thus distributed on the sea-bottom would displace enough water to cause an elevation of the mean ocean-level to the extent of at least three inches in 10,000 years.

An attempt is then made to compute the number of such periods of 10,000 years that must have elapsed during the accumulation of the immense mass of freshwater deposits said to exist in the valley of the Mississippi. The calculation is made from the data collected by

observers in America, as to the extent of the deposits in question: and it is supposed, first, that in former periods the same quantity of mud, as at present, has been annually carried into the Gulf of Mexico; and secondly, that the amount of sediment deposited in the delta and plains of the Mississippi does not exceed *one-tenth part* of the solid material which has been carried out (suspended in the water of the river) into distant parts of the Gulf of Mexico, or into the Atlantic itself. From the data submitted, it would appear that the accumulation of the alluvial deposits of the Mississippi must have occupied a great number of periods, during each of which a mean elevation of the sea-level to the amount of at least three inches may have occurred; and that the removal of detritus from the 1,100,000 sq. miles of North America drained by the Mississippi would (if annually carried on at the same rate as at present) reduce the mean surface-level of that district one foot in 9000 years; whilst the Ganges would produce the same effect on the area it drains in 1791 years.

The general conclusion arrived at is, that the sea-level cannot be considered as stationary for practical geological purposes, since the operation of present physical causes would produce a considerable change in its height, even during the construction of a recent deposit like that in the valley of the Mississippi, which may be called small and local compared with those older formations familiar to geological observers.

As the subsidences and elevations of the crust of the earth would be accompanied by alterations of the area of the sea-bed, the frequency of such movements would necessarily furnish additional reasons for not considering the sea-level permanent for the lengthened periods requisite for the accumulation of sedimentary deposits of any magnitude.

Lastly, the author directs attention to the difficulty of finding any test by which to distinguish strata gradually accumulated during a long-continued upward movement of the sea-level, from those strata formed on a sea-bottom slowly subsiding while the ocean-level was stationary. In either case no change of depth of water may have occurred of sufficient importance to cause the removal of the Mollusca inhabiting the locality, and therefore the discovery of *the same species of organic remains from top to bottom of a thick deposit* is not an absolute proof (as has been supposed) that gradual subsidence has occurred during the formation of that particular deposit, for the condition of equal depth of water during any deposit might be produced either by subsidence of the sea-bottom, or elevation of the sea-level, or by both conjointly. In discussing these questions, the author has not assumed that during gradual subsidences or gradual elevations, greater denudations or depositions would occur, than when the level of the land and sea-bottom was stationary; because it is not certain either that during such gentle oscillations the forces that would produce denudation are sensibly increased or diminished, or that the rocks which are brought within the reach of denuding forces are necessarily more easily worn away than those which were previously exposed to the same influences. Even if, in ancient periods, the rate

of denudation were greater than at present, and the supplies to rivers more extensive, the fluctuations of the sea-level and the elevation of the beds and plains of rivers would have been proportionally greater; and there would still have existed some localities where the rate of the formation of the alluvial plains near the sea kept pace with the elevation of the waters; so that, as at the present time, conditions would have existed for the accumulation of fluviatile strata containing terrestrial remains without the occurrence of any subsidence of the land. Hence it would be difficult to determine, when examining sections of thick fluviatile strata, whether these accumulations of detrital matter had been formed during subsidence of the land, or during that gradual elevation of the level of rivers and seas arising from the continued operation of ordinary physical causes.

January 5, 1853.

Edward Joseph Lowe, Esq., and Thomas Allison Readwin, Esq., were elected Fellows.

The following communications were read:—

1. *Notice of the Discovery of* Fossil Plants *in the* Shetland Islands. By the Rt. Hon. Henry Tufnell. *In a letter to Sir R. I. Murchison, F.G.S. With Remarks on the Fossil Plants*, by Dr. J. D. Hooker, F.R.S., G.S.; *and on the Sandstone in which they occur*, by Sir R. I. Murchison, F.R.S., G.S.

I shall be much obliged if you will present to the Geological Society, for me, the accompanying fossils, which I procured this year during a visit to the Shetland Isles, from a quarry, called the South Ness Quarry, about a quarter of a mile from the Tower of Lerwick. I obtained, with the fossil, a portion of the matrix in which it was imbedded, and as I believe no fossil of this description, if it be a Calamite, has been discovered in the Old Red Sandstone, I thought it might not be unworthy a place in the Museum of the Geological Society.

A very intelligent master mason in the Town of Lerwick, has in his possession some fossils of a similar kind, which were dug out of the same quarry, but I thought that this specimen might be sufficient.

Note on the Fossil Plants *from the* Shetlands. By Dr. Joseph D. Hooker, F.R.S., G.S.

I have examined very carefully the specimens of fossil plants communicated by Mr. Tufnell. All are in a very unsatisfactory state, but appear to belong to two species of *Calamites*, which, the articulations being nearly effaced, may be referable to known species, or may be altogether new. Had such specimens been collected in the Carboniferous formation, they would have been rejected as quite undeterminable; coming, however, as they do, from an older formation which has not been proved to contain fossil vegetables, they have

a peculiar value, and should be kept, in the hope that further light may be thrown upon them. The absence of articulations may be a character of these fossils, and not due to obliteration, though such obliteration is common in specimens of Calamite from the Carboniferous sandstone, and it is said that *Calamites* of considerable length have been found, presenting no appearance externally of articulations, whilst the cast always presents them. It should also be remarked, that there are obscure traces in two specimens of transverse raised knobs and bars (perhaps spirally arranged), crossing the striæ obliquely: these may indicate a peculiar character of the plants, but more probably have been caused by pressure during silicification.

Note on the AGE *and* RELATIVE POSITION *of the* SANDSTONE *containing* FOSSIL PLANTS *at* LERWICK *in the* SHETLAND ISLES. By Sir RODERICK I. MURCHISON, F.R.S., G.S.

IN presenting to the Society, on the part of my friend the Right Hon. Henry Tufnell, the specimens of fossil plants which he brought last summer from Lerwick, in the Shetland Isles, and on the botanical affinities of which, Dr. Hooker has reported at my request, I suggested that the rock in which these remains occurred must be considered as the upper member of the Old Red Sandstone.

Having traced sandstones of similar lithological character from the south side of the Murray Firth near Elgin through Ross and Caithness to the Orkney Islands, and having seen that in their range they everywhere constitute the upper member of the Old Red Sandstone, I could not entertain a doubt that the "superimposed secondary Shetland sandstone" of Dr. Hibbert* was of similar age. A mere inspection of the Map of that author showed that the crystalline rocks of Shetland were overlaid by conglomerates, schists, flagstones, and sandstones, as in the Orkney Islands and the adjacent mainland of Caithness. I am confirmed in this opinion, by learning from Mr. Tufnell, that fossil fishes had also been found in the Isle of Bressey, adjacent to the port of Lerwick.

Since then, I have consulted the only two living geologists with whom I am acquainted who have actually visited Shetland, Dr. Traill, and the Rev. Dr. A. Fleming, and I find that they both entertain the same opinion as myself concerning the age of the sandstones in question. The latter, though not so fortunate as to procure specimens of any animal remains, thus speaks of the few vegetable remains he met with:—"Some of these, usually very indistinct and often converted into anthracite, resembled the leaves of flags, whilst other specimens bore a remote analogy to that I supposed might have been a compressed *Sternbergia*. The general character of the rocks led me to regard them as nearly of the age of the *grey sandstone*, and a part of the series occurring in Caithness and Orkney, &c."

Dr. Traill, who is so well versed in the structure of the Orkney Islands, and is known to palæontologists as the discoverer of many of

* Description of the Shetland Islands, with a Geological Map, Plates, &c. 4to. Edinburgh, 1822.

the beautiful forms of "Old Red" ichthyolites published in the works of Agassiz, informs me that he has twice visited Shetland; his first visit having been so far back as 1803, and his last in 1852, or after an interval of forty-nine years! He states that to the north of Lerwick, the sandstones and flags pass downwards into conglomerates, which rest upon mica-slate, gneiss, granite, and hornblende rocks. In the cliff hills, on the contrary, which are the spine of the southern projection of the chief island, clay-slate, with occasional beds of limestone, also reposes on the primary rocks. Thus, we are presented in the Shetland Isles with a series of the same rocks which abound throughout the northern Highlands of Scotland, the oldest primary rocks being succeeded first, in some places, by clay-slates and limestones which may partially represent the Silurian rocks, and in others by conglomerates, flagstones, and sandstones, the last of which, dipping off from, and overlying all the other rocks, are the light-coloured sandstones in which the fossil plants of Lerwick occur.

Sustained by the opinions of such experienced geologists as Drs. Fleming and Traill, both of them acquainted with the structure of Shetland, I continue in the belief, that the sandstone of Lerwick is of the same age as the rocks of Elgin, Burghead, Tarbet Ness in Ross, and Dunnet Head of Caithness, all of which Prof. Sedgwick and myself described as constituting the uppermost member of the Old Red Sandstone*, and as overlying the Caithness flagstones with their numerous ichthyolites.

Whether, through the discoveries of fossils, this rock may eventually be classed as the bottom of the Carboniferous rather than as the summit of the Old Red or Devonian group, is a matter of interesting speculation, now that the land plants from Lerwick and the *Telerpeton* of Mantell† from Elgin have given characters to these sandstones which were unknown when our classification was suggested.

The order of superposition is, however, clear and undisputed; and the strata in question form the uppermost band of a connected series of conglomerates, flagstones, schists, and sandstones which constitute the Old Red Sandstone as defined by my associate and myself.

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2. *Notice of the Occurrence of an* ELYTRON *of a* COLEOPTEROUS INSECT *in the* KIMMERIDGE CLAY *at* RINGSTEAD BAY, DORSETSHIRE. By the Rev. P. B. BRODIE, M.A., F.G.S.

ALTHOUGH the occurrence of a single Elytron of a Coleopterous Insect scarcely appears at first sight worthy of attention, yet, since the discovery of remains of Insects in any stratum or fresh locality may lead other observers to obtain additional forms of Insect life from rocks as yet unproductive in this respect, and thereby give us an insight into the characters of those which flourished at such

* Trans. Geol. Soc. Lond. 2 Ser. vol. iii. p. 125, 1828. For a description of the strata of Dunnet Head and the Orkneys, see a previous memoir by myself, in Trans. Geol. Soc. Lond. 2 Ser. vol. ii. p. 314.

† See Quart. Journ. Geol. Soc. vol. viii. p. 97 *et seq.*

particular epoch, it appears desirable to record this discovery of an Elytron in the Kimmeridge Clay on the coast of Dorset*. Geologists are now generally well acquainted with the fine section afforded by the cliffs at Ringstead bay, near Weymouth, formerly well known as "the burning cliff." In the upper part of the cliff, not far from its junction with the Portland Sand, the Kimmeridge Clay is traversed by a bed of yellow, sandy, laminated stone, about 2 feet thick, containing Fish-scales and teeth of a species of *Hybodus*, which reminded me strongly in its lithological characters of the "fish bed" in the Upper Lias. This is succeeded by thick strata of dark-coloured shale and clay, containing large blocks of septaria, in one of which I discovered a striated Elytron of a small Beetle. Many shells are dispersed throughout these argillaceous beds, among which may be enumerated several species of *Ammonites*, with the bright pearly lustre beautifully preserved, *Cardium*, *Arca*, *Leda*, *Orbicula*, *Lingula*, and *Aptychus*, &c. Lower down there are some smaller nodules of limestone, which afford several minute species of Univalves and a few *Lingulæ*. The strata at the base of the cliff on the shore, as they approach the Coral Rag, become more sandy and coarser, and yield many species common to the latter; indeed, there appears to be a considerable difference between the fossils of the upper and lower part of the Kimmeridge Clay at this spot.

In a deposit containing an assemblage of organic remains so decidedly marine, we cannot expect relics of Insects to be usually very abundant except in a few favoured localities, but, however rare, the fact of the existence of Insect life at this period of the upper Oolitic series is evident. Within the last few years considerable additions† have been made to our knowledge on this subject, and remains of Insects are now known to be widely and extensively distributed throughout many formations of very different age, in greater or less abundance.

With regard to other organic remains lately obtained from the Kimmeridge Clay,—in the collection of Mr. Groves, stationer, at Wareham, I noticed portions of one or more species of large fish, which appear to be new, the most perfect having the head and fragments of the body attached‡. Some large *Ostreæ*, *Ammonites*, *Cardium*, *Rostellaria*, and other shells, and a fine *Sepia*, are associated with them. They were obtained in the black, bituminous shale at Kimmeridge. On the coast hereabouts a magnificent paddle of a *Pliosaurus* was lately discovered, and is now deposited in the Museum at Dorchester. The animal to which it belonged must have been of enormous size, and from the perfect state of the bones, in all probability the entire skeleton is preserved in the cliff.

* The specimen was unfortunately broken, and consequently is too imperfect to admit of its being figured or described.

† Among these may be mentioned the Elytra in the Bagshot Sands, noticed in another communication to the Society, and the more recent discovery of Elytra of Insects in the Hastings Sand, in the Isle of Wight, by Prof. E. Forbes. Some insect remains have also been procured from the Cretaceous series in Germany.

‡ Sir P. Egerton has lately seen these fossil fish, and he informs me that they are all new.

3. *On the Occurrence of the* Remains *of* Insects *in the* Tertiary Clays *of* Dorsetshire. By the Rev. P. B. Brodie, M.A., F.G.S.

The Tertiary strata of sands and clays at Corfe in Dorsetshire, which have been for some time known to contain a numerous and interesting flora, have afforded a large collection of remains of plants, chiefly dicotyledonous leaves, to the researches of my cousin, W. R. Brodie, Esq., and my friend, the Rev. G. H. Austen. In addition to the plants, the former discovered a few small elytra of Coleopterous Insects which belong to the families *Curculionidæ* and *Buprestidæ*. Mr. Westwood, who has kindly examined them, states that they belong to the ordinary types of the existing fauna*. This discovery is the more interesting on account of the extreme rarity of any relics of Insects in our British Tertiaries; and it appears to be their first occurrence in this portion of the series, although Dr. Mantell, in his 'Geology of the Isle of Wight,' mentions that Mr. Webster had observed traces of Insects in the London Clay near Parkhurst†, but no description or figures are given. It should be observed that the Curculionideous elytron was obtained two or three feet below the leaf-bed, where leaves are comparatively scarce, but the other elytra were associated with the plants.

Mr. Prestwich informs me that he considers the Corfe clays and sands to belong, probably, to the lower part of the "Bagshot Sand," but he does not feel quite confident as to their true position, which is rendered the more difficult to determine, from the apparent absence of the London and Mottled Clays in that district. The following section, in descending order, of one of the numerous clay-pits which are opened between Corfe and Wareham, is given in the Rev. Mr. Austen's valuable monograph on "the Geology of the Isle of Purbeck and the South-west Coast of Hampshire‡" :—

	feet.
Bed of lignite, about	10
Grey clay with carbonized leaves	2
Yellow sandy clay with leaves	2
Ferruginous band, a few inches.	
White sand, about	30
Pipe-clay	11 to 14
Total	58

Many varieties of leaves have been obtained from this pit, especially one very fine specimen belonging to a plant, apparently allied to the Date-palm, and others belonging to several species of Willows. The leaves are often of large size, and in a beautiful state of preservation,

* These interesting Insect-remains will be figured and described at some future opportunity.

† Geology of the Isle of Wight, p. 140.

‡ Pamphlet, 8vo. Blandford, 1852.

far more so than those which I obtained many years ago at Bournemouth*. A fine collection has been made by Mr. W. R. Brodie, and is now deposited in the Museum at Dorchester. It is to be regretted that this remnant of our Tertiary flora has not yet been figured or described, but there appears to be a considerable difficulty in determining the species. This, however, is more desirable, inasmuch as a large number of plants have been procured in different parts of the series, both above and below the London Clay, and, in many cases, they appear to belong to distinct groups.

In one of the pits in the neighbourhood of Corfe an unusually rich bed of pipe-clay has lately been found.

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4. *On the* GEOLOGY *of* LABUAN†. By J. MOTLEY, Esq.

[Communicated by Sir H. De la Beche, F.G.S.]

[Abstract.]

THE Island of Labuan is composed of alternating beds of clays and sandstones, the former sometimes containing ironstone. Coal-seams are found in several places, and appear to be associated in groups. The principal beds of coal occur in the northern part of the island, between two ridges of sandstone hills, one of which, the most southerly and in some places upwards of 300 feet high, runs from the South Bluff of Tanjong Kubong (near the northern extremity of the island) in a S.S.W. direction to Luke Point on the western coast; and the second ridge, less regular, though at places higher than the first, commences a few hundred yards to the north of this Bluff, and runs parallel to the first ridge towards Heath Point. The beds dip conformably to the N.N.W., at angles varying from about 25° (at Tanjong Kubong) to about 70° (at Sawangan Pagar). The following is the succession of beds (in ascending series) seen in the cliffs at Tanjong Kubong, going northward from South Kubong Bluff:—

1. Blue shale, including many extremely thin layers of very argillaceous sandstone; with indistinct traces of shells‡:—probably 50 or 60 yards thick.

	feet.	in.
2. Coarse white sandstone	10	0
3. Very coarse conglomerate of water-worn pebbles of quartz, coal, hard red sandstone, white sandstone, and hæmatite, cemented by siliceous oxide of iron	3	0
4. Sandstone	12	0
5. Coaly sandstone with quartz pebbles	4	0
6. White sandstone, with pebbles of coal, sandstone, and blue shale, the last still containing traces of fossil leaves	21	0
7. Hard reddish sandstone	1	6
8. Hard, close, white sandstone	9	6

* Proceedings of the Geological Society, vol. iii. p. 592.

† This paper has been printed in full in the 'Journal of the Indian Archipelago,' vol. vi. No. 10. October 1852.

‡ Fragments of shells, that apparently belong to one species of small bivalve, nearly orbicular, very thin, and smooth.

		feet.	in.
9.	Conglomerate of quartz, sandstone, and coal pebbles, cemented by very fine white sandstone, various in texture	30	0
10.	Blue clay	1	6
11.	Coaly earth	0	6
12.	Sandstone; below, varying from fine freestone to coarse grit, and containing many particles of coal; in the upper beds grey, very hard, and can be raised in large blocks	47	0
13.	White clay vein	0	2
14.	White soft sandstone	4	6
15.	Hard blue compact clay with occasional nodules of ironstone	3	9
16.	Very hard blue sandstone	0	6
17.	Laminated sandy clay	1	10
18.	Very tough, unlaminated blue clay, rapidly decomposing in the air	3	3
19.	Brittle, laminated carbonaceous shale	0	3
20.	Coal, very compact like cannel coal	0	8
21.	Soft coaly fire-clay, with small nodules of ironstone	3	0
22.	Coal, main seam; with fossil trees and resin, and occasional water-worn pebbles of coal; averaging about	11	0

The coal appears to be composed, for the most part, of prostrate trunks of large trees, slightly compressed, and crossing each other in all directions. The fossil wood is dicotyledonous, and exactly resembles in microscopical structure that of the Dipteraceous trees now forming the mass of timber growing on the island. What makes the resemblance of this coal to the wood of the *Dipteraceæ* still more striking, says the author, is the existence of the thickly scattered masses of semitransparent resin dispersed through its substance; this when burnt diffuses the fragrant smell of recent resin*, and is used with fresh *dammar* in making torches. In some coal beds on the River Bintulu, in Borneo, it is exceedingly plentiful. The editor of the Ind. Arch. Journ. observes, that specimens of coal from Riteh, on the east coast of Sumatra, near the Indrageri, contain much of this resinous substance.

		feet.	in.
23.	Hard carbonaceous shale, often dying out	3	0
24.	Blue clay, scarcely laminated, with nodules of ironstone, casts of a bivalve, and remains of plants ... about	60	0

In this bed are found occasionally erect trunks of small size, probably of dicotyledonous trees, and more rarely palm-trunks, also erect, but silicified. Impressions of leaves are very abundant, but rarely perfect. Of these, Mr. Motley states that he has "procured identifiable specimens of nine species of Dicotyledons, of which two so closely resemble existing species of *Barringtonia* and a probably Dipteraceous plant which yields an oily resin, named *Kruing oil*, much used for protecting wood, that it is difficult to believe them not identical." He has obtained also "two or three? species of Ferns, a large flag-shaped leaf like a *Crinum*, and something closely resembling a large thick-stemmed *Usnea* or Confervoid Alga. Also four or perhaps five species of Palms, one flabelliform and four pinnate, one of the latter very closely resembling an existing species." These vegetable remains are chiefly, but not entirely, in the lower part of

* For an account of this resin, see Kew Annals of Botany, 1852.

the bed; sparingly among them, but more abundantly in the upper half, are found a good many casts of Bivalves, much resembling some species of *Unio*. The calcareous part of the shell is always removed, but the membranous epidermis appears to remain, generally as a sort of varnish upon the cast, but occasionally free in the cavity formerly occupied by the shell. The casts are of ironstone, and are usually much fissured.

		feet.	in.
25. Coal, about 1 ft. 6 in.,—but at one point inland nearly		5	0
26. Blue clay with ironstone	about	50	0
27. Coal	about	1	2
28. Blue clay	about	0	6

29. Sandstone.
30. Above all these is another series of sandstones, similar to those below the carboniferous clays, but rather harder. About the middle of these sandstones is a tolerably continuous, though not quite regular, course of water-worn blocks of coal, some as heavy as 2 cwt. They lie sometimes in groups and sometimes several yards apart, and have been traced at several points inland.
31. A short distance above these sandstones is another small vein of coal, occasionally divided by a narrow band of stone.
32. Further along the cliffs* occurs an unlaminated blue shale, divided by several bands of a very hard siliceous indurated clay, full of nodules of siliceous ironstone; with shells and *Algæ*.

Here Mr. Motley has found the following fossils. In the shale—

	Species.		Species.
Cardium	2	Ostrea	1
Tridacna	1	Tellina	1
Arca	1	Univalves, uncertain	4

In the hard bands, chiefly as casts—

Murex	1	Pecten	1
Turbo?	1	Ostrea	1
Cerithium or Terebra	2	Bivalves, uncertain	2
Serpula	1		

Narrow carbonaceous ribands intersect the clay in every direction, and appear to be the remains of *Algæ*.

An almost exactly similar deposit to this bed of shale, and containing very similar fossils, Mr. Motley observed in the bed of the Tukuruk River, near Bruni.

In the south-eastern part of the island, the sandstones and clays at Pasley Point and Tanjong Tarras, containing occasional thin seams of coal with fossil resin, dip N.b.E.$\frac{1}{2}$E. at an angle of about 25°, according to Mr. Bellot's section of this part of the coast, presented to the Society in 1847. In this neighbourhood, north of Tanjong Tarras, Mr. Motley has found a fossiliferous sandstone, about half a mile south of Mombedi Creek, and less than a mile inland [and therefore possibly on the strike of some of the beds about the middle of Mr. Bellot's section]. This is a soft, light brown sandstone, having a strong smell of iodine. It is divided by partings composed of com-

* At about 1500 yards beyond either bed No. 24 or No. 31,—see Journ. Ind. Arch. *l. c.* p. 567.—Ed. Q. G. J.

minuted shells. Among the more perfect shells found in this deposit Mr. Motley has recognized—

	Species.		Species.
Pyrula	1	Terebra?	2
Turbo?	1	Arca*	1
Cerithium	3	Solen	1
Fusus	1	Terebratula?	1
Oliva	1	Bivalves, uncertain	7

Together with these are leaves closely resembling those of the common Mangrove, fragments of wood, traces of Fucus?, tracks of Crustaceans, and borings of Annelids.

Near the Mombedi Creek, a thin bed of sandy shale, exposed in a low cliff on the beach, is very full of impressions of two species of *Pecten* and an *Ostrea* or *Avicula*.

Coal-beds similar to those of Labuan exist also on the western coast of Borneo, as far north as Mengkabong and at Gantisau, in Pulo Gaya; and to the south they are found near the town of Bruni, where several seams of excellent coal occur, also on the Barram, Bintulu, and Rejang rivers.

Mr. Motley considers it probable that the granitic range running through Borneo, in a south and south-westerly direction from the Keena Baloo, may constitute the eastern limit of this extensive coal-field, which, he suggests, may have been formed in the estuary of some great river or system of rivers, draining some ancient continent to the northward; occasional floods having brought the materials for the pebble-beds and conglomerates with which the coal-seams, shales, and sandstones are frequently interstratified. Such a river, he adds, may have flowed from the high land of Central Asia over what is now the basin of the China Sea, and in the course of ages have deposited in its vast delta the Bornean coal-field, which was afterwards tilted† into its present position by the eruption of the vast granitic mass of Keena Baloo.

Mr. Motley's communication contains also much general information on the topography and geology of Labuan and its islands (a MS. map of which accompanies the paper), and the neighbouring parts of Borneo.

Note.—For notices of the coal of Bruni and Labuan; of the eastern side of Borneo, near the River Coti or Gooty; of Junk-China, an island on the coast of the Malay peninsula of Formosa; and of the S.E. coast of Sumatra, see Quart. Journ. Geol. Soc. vol. iv. p. lxi, xcvi, and p. 50; and Journ. Ind. Archip. 1847, vol. i. pp. 80, 90, 145, 153, &c. A notice also of the coal-workings in the northern part of Formosa is given in Mr. Bellot's MS. communication in 1847.

* Different from that at Tanjong Kubong.

† In Pulo Daat, Pulo Loobedan, and the neighbouring coast, the rocks are nearly vertical; but at P. Loobedan and elsewhere there are considerable local contortions. At Bruni, to the south, the dip is nearly north and very steep, as it is also at Tanah Merah, about 20 miles north of Labuan. At Mangatal and Mengkabong also the dip is northerly, but at a less angle.

January 19, 1853.

John Brogden, Jun., Esq., was elected a Fellow.

The following communications were read:—

1. *On the* Remains *of a* Reptile (Dendrerpeton Acadianum, *Wyman and Owen*) *and of a* Land Shell *discovered in the* Interior *of an* Erect Fossil Tree *in the* Coal Measures *of* Nova Scotia. By Sir Charles Lyell, F.R.S., V.P.G.S. &c., and J. W. Dawson, Esq.

[Plates II., III., IV.]

Descriptions and sections of the Coal-formation of Nova Scotia, and particularly of the cliffs called the South Joggins, have been published by Messrs. Jackson and Alger*, Mr. Brown†, Dr. Gesner‡, Sir C. Lyell§, and Mr. Logan‖. In September last (1852) the authors of the present notice re-visited and re-examined the strata in a part of these cliffs, with a view of ascertaining what may have been the particular circumstances which favoured the preservation of so many fossil trees, at so many different levels, in an erect position; such a position being a rare and very exceptional fact in the coal strata of North America generally. We were also desirous of obtaining additional evidence on a point which is still a matter of controversy in the United States and elsewhere (although we ourselves were already satisfied with the evidence adduced by Mr. Binney¶ and others), namely, the relation of *Stigmaria*, as a root, to *Sigillaria*. We also directed our special attention to the difference of the deposits enveloping the upright trees, and those which fill the trunks themselves, forming casts within a cylinder of bark now turned to coal, the central wood of the trunk having decayed. We searched diligently for fossils in these stony casts, suspecting that organic bodies preserved in so peculiar a situation might differ from such as are buried in ordinary subaqueous strata. With this object we employed a labourer to dig out many vertical trees from the cliffs, so that we might break them up and carefully examine their stony contents. To clear out the trees, so as to expose to view both their trunks and roots, is a work of no small bodily labour.

We reserve for a future communication to the Society an account of the general results which we obtained from an inspection of a series of coal-measures 1400 feet in thickness, and shall confine our present remarks to a few strata, not more than 10 feet thick, which enclose certain vertical trees;—one of these trees having Stigmarian roots,

* See Jackson and Alger on the Mineralogy and Geology of Nova Scotia, Sill. Amer. Journ. xiv. p. 305, 1828, and Mem. of Amer. Acad. of Arts and Sciences, vol. i. New Ser. 1833. Cambridge, Mass.

† Reports on Nova Scotia Coal Fields, 1829.

‡ Remarks on the Geology and Mineralogy of Nova Scotia, 1836.

§ Travels in North America, 1845, vol. ii. p. 180.

‖ First Report of Survey of Canada, Appendix, 1845.

¶ See E. W. Binney, on the Dukinfield and St. Helen's *Sigillaria*, Quart. Journ. Geol. Soc. vol. ii. p. 392. 1846.

and another containing in its interior the first examples yet known in America of Reptilian bones, together with what we believe to be a Land Shell, of which last also no instance seems to have been previously observed in rocks of the Carboniferous æra. After we had already, in the course of this investigation, met with fragments of Plants, such as Ferns, *Poacites*?, *Nœggerathia*?, *Sigillaria*, *Stigmaria*, and Calamite in the inside of several trees, we at length found near the base of an upright trunk some dermal plates, together with bones, one of which we conjectured to be the femur of a Reptile, feeling sure at least that it differed from any Fish bones with which we were acquainted. This led us to return next day to examine the same trunk more thoroughly. We accordingly broke up the remaining portion, and found what we imagined might possibly be the jaws and teeth of a *Labyrinthodon*, which we supposed to belong to the same individual as the bones. These osseous remains were scattered about in the interior of the trunk among fragments of wood converted into charcoal, as if they had accumulated while the tree was rotting away. All the fragments were cemented together by a dark-coloured calcareo-argillaceous and sandy matrix. From their position in the tree, we concluded, or rather guessed, the fossil relics to be those of an air-breather, but pretending to no sufficient osteological knowledge to determine a point of such importance, we lost no time in submitting the collection to Professor Jeffries Wyman, of Harvard University, at Boston, who soon declared his opinion that the bones of the extremities resembled those of the Batrachian Reptile called *Menobranchus*, which now inhabits the Ohio river and Lake Champlain. In regard to its dimensions, he estimated this fossil ichthyoid quadruped to have been between 2 and 3 feet in length. In breaking up the fragments of rock, Professor Wyman detected in the same matrix a series of nine small vertebræ, two of them having what appeared to be short ribs connected with them (like those of a Salamander). These vertebræ he believes to be dorsal or lumbar, and to have belonged to an adult individual of a different and much smaller species of reptile, not exceeding 6 inches in length, whereas the *Dendrerpeton Acadianum* was probably $2\frac{1}{2}$ feet long.

Professor Wyman, feeling considerable diffidence as to his determination, in consequence of his limited means of osteological comparison, requested one of the authors to show his notes, together with the specimens, to Prof. Owen, before they were laid before the Geological Society. To this proposal Prof. Owen has promptly and kindly acceded, fully confirming the principal conclusion to which the American anatomist had arrived, namely, that the characters of the fossils are those of Perennibranchiate Batrachians. The Hunterian Professor has also, in compliance with a suggestion of Dr. Wyman, added notes of his own on several points where he differed somewhat in opinion as to anatomical details. Prof. Quekett, of the College of Surgeons, has had the kindness to examine microscopically longitudinal and transverse sections of one of the larger bones; and he states that it exhibits very decidedly Batrachian structure, and that the bone-cells (Pl. III. fig. 8) closely resemble those seen

in *Menopoma* and *Menobranchus** (fig. 10). Prof. Quekett has also found similar batrachian structure in the small vertebræ above alluded to. (See Pl. III. fig. 9.)

In breaking up the rock in which the reptilian remains were imbedded, Dr. Wyman found another fossil body, which he and Sir C. Lyell immediately suspected to be a Land-Shell allied to *Pupa* or *Clausilia,* having the central whorls larger than the anterior and posterior ones, and exhibiting the same kind of striation as characterizes the shells of these pulmoniferous mollusks. Dr. Gould, of Boston, detached the same fossil more completely from the matrix (see Pl. IV. figs. 1, 2, 3, 4); but he was unable to discover the mouth, so as to enable a conchologist to determine the genus with precision. He observed that in its form and striation it bore no resemblance to any known marine shell. M. Deshayes, when the fossil was shown to him, declared at once his opinion that it was the shell of a pulmoniferous and terrestrial mollusk, of the same family as that to which *Helix* and *Pupa* belong.

[Doubts, however, having been expressed by other palæontologists (since this paper was read) as to the correctness of this conclusion, the specimen was submitted to Prof. Quekett for microscopical examination. Part of the striated or finely grooved surface, on being magnified 50 diameters (see Pl. IV. fig. 5), presented exactly the same appearance as a portion, corresponding in size, of the surface of the common English *Pupa juniperi* (see Pl. IV. fig. 6). On making sections of such parts of the fossil shell as were not in too crystalline a condition to exhibit structure, Prof. Quekett detected the same prismatic or hexagonal tissue and the same tubular structure as are generally characteristic of the shells of mollusca, and as may be seen in the recent *Pupa, P. juniperi,* before alluded to. See Pl. IV. figs. 7–14. One of the sections, moreover, exhibited what may probably have been a portion of the columella and spire somewhat crushed (Pl. IV. fig. 7, upper part), for, as will be seen by the magnified representation of the entire shell (Pl. IV. figs. 2–4), it had been subjected to considerable pressure, and had been slightly flattened and fractured.—March 21, 1853.]

More than usual hesitation has been felt in acceding to the conclusion that this fossil belonged to the family *Helicidæ,* inasmuch as no land-shell had previously been observed in any palæozoic rock; but the mode of occurrence of this body appears in perfect accordance with the idea of its being referable to a pulmoniferous mollusk, since it was lying among the rotten wood in the interior of a hollow tree, the upper part of which doubtlessly projected into the air 8 or 9 feet above the roots, or into the water during river inundations.

In connexion with the reptilian remains, it may not be irrelevant to observe, that Mr. Logan and Dr. Harding have previously called attention to the foot-prints of a quadruped imprinted on sandy slabs,

* In a plate of the volume of the Histological Catalogue, Mus. Coll. Surg., on which Prof. Quekett is now engaged, sections of the bones of recent Batrachians are magnified on a uniform scale, namely 440 diameters, and the identity of size and character of the bone-cells can at once be recognized.

in a lower part of the coal-measures of Nova Scotia, at Horton Bluff, which foot-prints might well correspond in size with the *larger* animal found in the South Joggins tree, assuming that the small vertebræ indicate a distinct species. Dr. Gesner has also mentioned in a letter to one of the authors, that he has discovered in the lower coal-measures of Parsborough a smaller series of foot-prints supposed to be those of an individual about 5 inches long, or of the size of the common small lizard of Nova Scotia. The mark of the tail between the rows of tracks is, he says, very perfect. These impressions deserve notice, as they may possibly have some relation to the smaller of the two reptiles above noticed.

The only indication of reptilian life detected in America previously to this discovery, in rocks of such high antiquity, were confined to foot-prints in the coal of Pennsylvania.

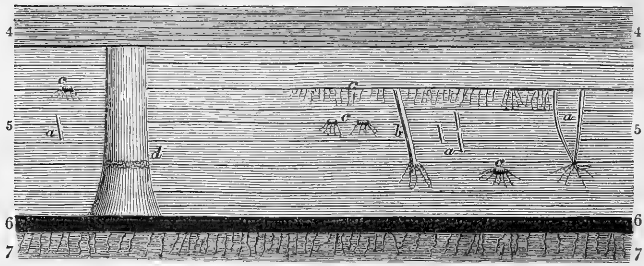
The following section, extracted from our field-notes, being part of a more complete list of the South Joggins strata, is given to enable the reader to understand the exact position of the fossil tree in which the bones occur. We have also subjoined a description of the strata immediately above and below the bed where the bones were found. The locality is that part of the South Joggins coast where vertical trees are most frequent, about half a mile eastward of the Coal Pier. A thickness of 600 feet of strata intervenes between the main coal, called the King's Vein, which is higher in the series, and the reptile-bearing bed, No. 5, see fig. p. 62, there being several thousand feet of well-characterized carboniferous strata both above and below the rocks containing the fossil forests. The dip at the place where the bones were met with is to the south 25° west, at an angle of 20°. The beds in the following section are mentioned in the descending order.

	ft.	in.
1. Grey sandstone (Grindstone), with prostrate carbonized trees and fragments of vegetable matter	25	0
(This bed is about 550 feet below the main coal.)		
2. Alternations of shale and bluish argillaceous sandstone, with two erect fluted trees, one of them with Stigmarian roots spreading in shale 3 feet above next bed	14	0
3. Coal and bituminous shale, with *Sigillaria, Stigmaria, Lepidodendron, Calamites,* and *Poacites* or *Nœggerathia?*....................................	0	14
4. Underclay, with rootlets of *Stigmaria,* resting on grey shale, with two thin layers of coaly matter.........	8	10
5. Grey sandstone, with three erect trees, one having Stigmarian roots; erect *Calamites* and stems of unknown plants. (*One of the erect trees in this bed contained the bones, teeth, &c. and land-shell above-mentioned.*)	9	0
6. Coal	0	6
7. Underclay, with *Stigmaria* rootlets	2	0

The bed No. 1 forms a high cliff and projecting reef, behind which the shore recedes and takes for a short space the direction of the strike of the beds. Owing to this circumstance an unusually large

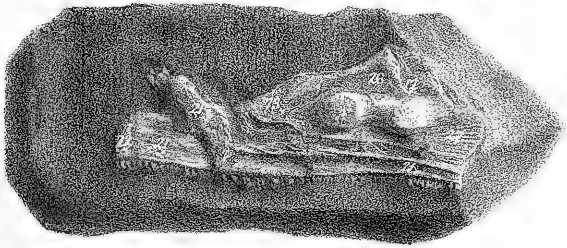
portion of the beds immediately underlying is exposed and accessible. Thus exposed, the sandstone No. 5 shows, on the beach, a stump 1 foot in height and 1 foot in diameter, having its surface-markings destroyed by the sea, but retaining two distinctly marked *Stigmaria* roots, one of them bifurcating at the distance of 2 feet from the stump. In the cliff are seen, in the same bed, *Calamites*, rooted and erect, a plant-stem, somewhat inclined, but apparently having roots attached, and a large vertical tree, 2 feet in diameter at base, and fluted irregularly, but without leaf-scars. This tree springs from the coal No. 6, and extends to the top of No. 5, but the *Calamites* and stems of some unknown plant are rooted at a higher level, and there are *Stigmaria* roots, apparently *in situ*, at three distinct levels in the sandstone. One of these levels corresponds to the broken tops of the Calamite stems, another to their base, and the third apparently to the roots of the first stump seen on the beach. These appearances are shown in the following section, which represents these fossils as seen from the shore above mentioned, which follows the strike of the beds.

Section of part of the South Joggins Strata.

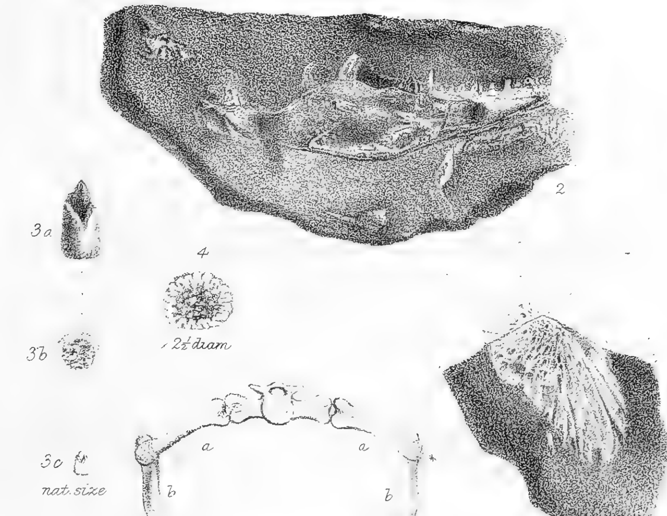


4, 5, 6, 7, beds referred to in the foregoing list of strata.
a, Calamites. *c*, Stigmaria roots.
b, Stem of plant, undetermined. *d*, Sigillaria trunk, 9 feet high.

In tracing this bed a little beyond the large tree represented in the section, see fig., we found on the beach another fossil tree, 22 inches in diameter, which had fallen from the bed No. 5, and had no doubt occupied a position similar to that of the large tree still standing. It was a cylindrical cast in sandstone, having on the surface flutings like those of *Sigillaria*, but without leaf-scars. In the lower part of the cast, the sandstone contained a large quantity of vegetable fragments, as above mentioned (p. 59), principally pieces of carbonized wood, leaves of *Nœggerathia* or *Poacites*?, and stems of *Calamites*. With these vegetable remains we found the bones, jaws, teeth, &c. before alluded to, all distinctly *within* the lower part of the cast, and scattered among the vegetable fragments contained in it, as if either washed in in separate pieces, or, more probably, mixed with the woody matter, when the animal fell to pieces through decay. A part of the vegetable matter present must have been introduced after the tree became hollow. The creature to which the bones belonged may, therefore,



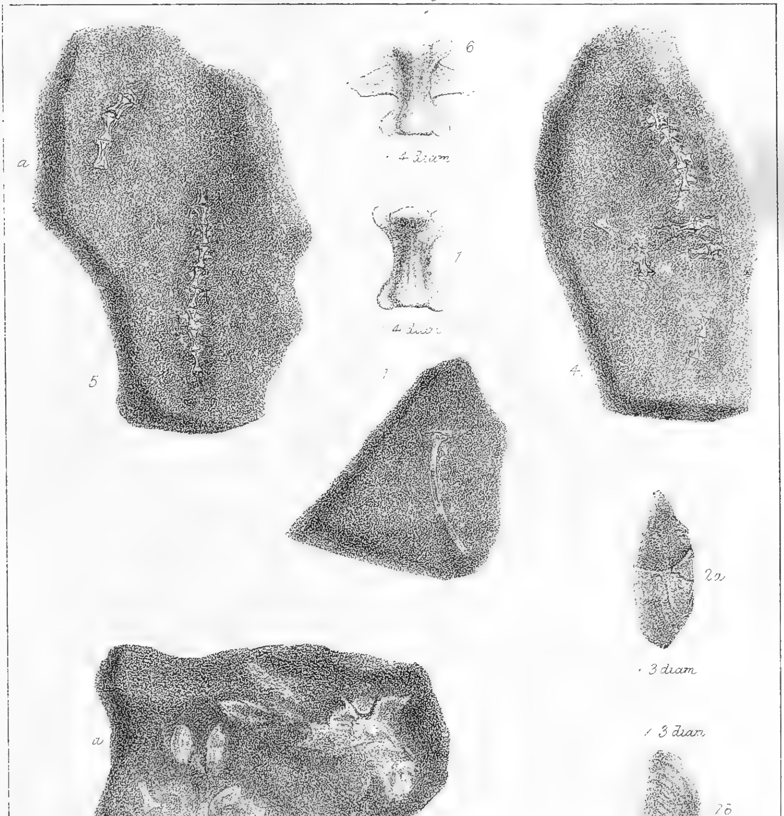
PARABATRACHUS COLEI. ½ nat. size



DENDRERPETON ACADIANUM

Jos. Dinkel del. et lith.

CARBONIFEROUS REPTILES

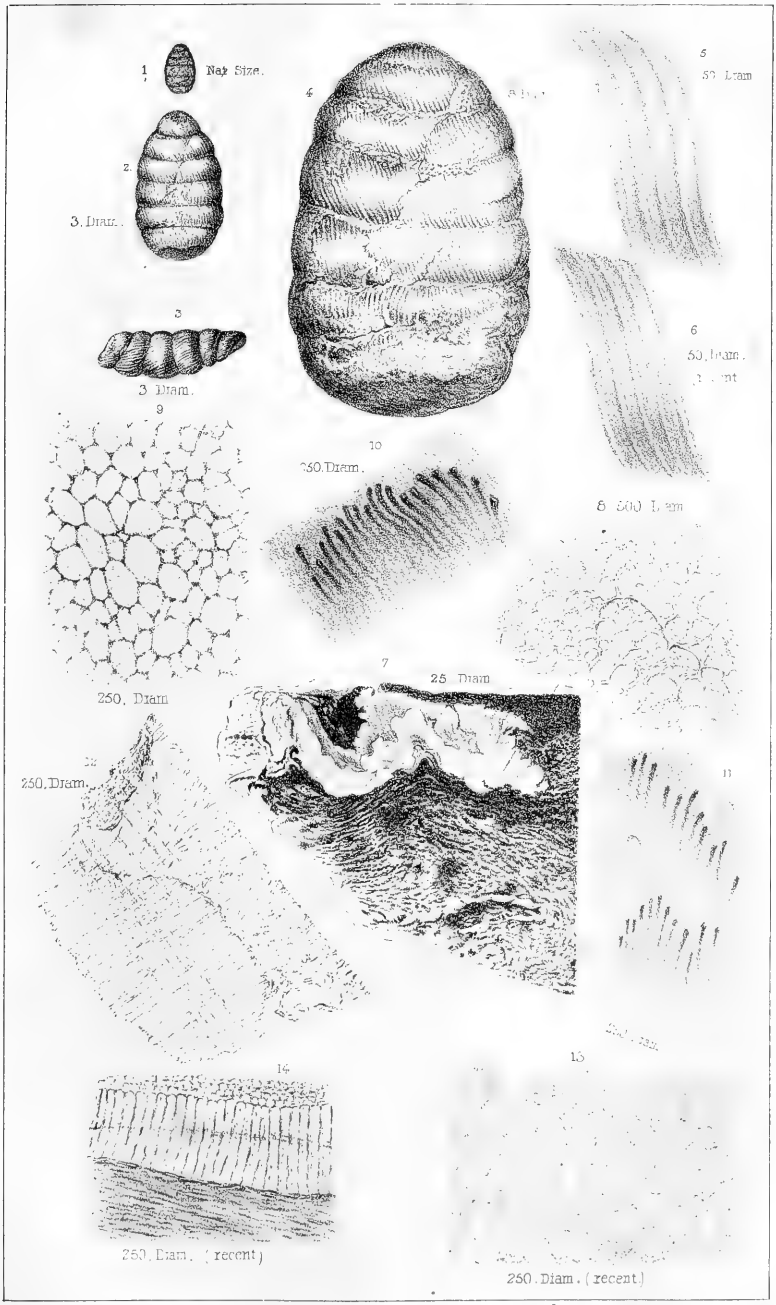


DENDRERPETON ACADIANUM

CARBONIFEROUS REPTILE

Jos Dinkel del et lith

Ford & West Imp 54 Hatton Garden



Jens Aldous Del et lith.

M & N. Hanhart. Imp.

"CARBONIFEROUS" LAND SHELL.

Nova Scotia.

either have been washed in after death, or may, when creeping on the surface, have fallen into the open pit caused by the decay of the tree, or it may have crept into some crevice in the trunk before it was finally buried in the mud and sand. The fragments of wood found with the bones, when sliced, show a dense irregular cellular tissue, with scalariform ducts, like those of Ferns. They therefore probably belong to *Sigillaria*, and may be parts of the woody tissue of the tree within which they were found.

The other vegetable fossils contained in these beds, and the circumstances under which they grew and were entombed, will be fully discussed in another communication to the Geological Society.

DESCRIPTION OF PLATES II., III., IV.

Plate II.

Fig. 1. Parabatrachus Colei. Portion of skull; half nat. size. 12, Post-frontal bone; 21, maxillary; 22, premaxillary; 26, malar; 27, squamosal; 73, lacrymal.
Fig. 2. Dendrerpeton Acadianum. Portion of lower jaw, with teeth; nat. size.
Fig. 3. Small tooth; *a*, *b*, magnified; *c*, nat. size.
Fig. 4. Base of larger tooth, magnified $2\frac{1}{2}$ diam.
Fig. 5. Cranial bone; nat. size.
Fig. 6. Iliac bone; nat. size.
Fig. 7. Humerus, with proximal extremity of the radius at *a*; nat. size.
Fig. 8. The bones of the pelvis and hind leg of the *Menobranchus*: *a a*, *b b*, the two elements of the iliac bone.

Plate III.

Dendrerpeton Acadianum.

Fig. 1. Rib bone; nat. size.
Figs. 2 *a*, 2 *b*. Dermal scutes, magnified 3 diam.
Fig. 3. Pharyngeal (?) teeth, and dermal scutes at *a*; nat. size.
Fig. 4, 5. Vertebræ of the smaller reptile; nat. size.
Fig. 6. Single vertebra; magnified 4 diam.
Fig. 7. Single vertebra from *a*, fig. 5; magnified 4 diam.
Fig. 8. Bone-cells from the iliac bone of the *Dendrerpeton Acadianum*, magnified 440 diameters.
Fig. 9. Bone-cells from the vertebræ of the smaller reptile.
Fig. 10. Bone-cells from the recent *Menobranchus*.

Plate IV.

Fig. 1. Land Shell from the interior of fossil tree, nat. size.
Fig. 2. ———, magnified 3 diam.
Fig. 3. ———, side view, magnified 3 diam.
Fig. 4. ———, magnified 8 diam.
Fig. 5. ———, striæ of the surface. }
Fig. 6. Recent *Pupa Juniperi*, ditto. } Magn. 50 diam.
Fig. 7. Fossil Land Shell, section of part of, magnified 25 diam.
Fig. 8. ————, microscopical structure of the same, showing hexagonal cells, magnified 500 diam.
Fig. 9. ————, section of a chipping, with hexagonal cells.
Fig. 10. }
Fig. 11. } ————, tubuliferous structure.
Fig. 12. ————, prismatic structure.
Fig. 13. Recent *Pupa Juniperi*, hexagonal cell-structure of.
Fig. 14. ————, prismatic cell-structure of.
} Magn. 250 diam.

Notes *on the* Reptilian Remains. By Dr. Jeffries Wyman, Professor of Anatomy in Harvard College, Cambridge, U.S.†

[Plates II. and III.]

1. Pl. II. fig. 6. This bone (on the specimen marked No. 1 ‡) resembles one of the bones of the pelvis of *Menobranchus*; its two articulating surfaces corresponding with those which are attached to the extremities of the sacral vertebra, fig. 8 *a*. The extremity, *a**, in *Menobranchus* is cartilaginous, but if this were completely ossified, the resemblance to the fossil becomes very strong.

The bone under consideration has a double articulating surface at one extremity, is contracted in the middle, and becomes broad at the other end, where it is quite thin. It has been compared to the lateral portion of the hyoid arch of ganoid fishes. In *Lepidosteus* and *Amia* the part which corresponds in shape with this bone consists of three pieces united by cartilage or ligament. (See Agassiz, Osteology of *Lepidosteus*, Poiss. Foss. vol. ii. pl. B. fig. 3, 37, 38, 39.) In the instance before us, the bone is undivided, and the form is quite different from that seen in any described species of *Lepidosteus*.

2. Pl. II. fig. 7. This bone (specimen No. 2) is somewhat similar to the preceding, but larger, and differing materially in its details. Of the two processes at the extremity, one is provided with a hemispherical articulating head, giving the parts a strong resemblance to the upper portion of a femur. At the other extremity the bone becomes broad §.

3. Pl. II. fig. 2. Specimen No. 3 contains fragments of a large portion of a jaw, with a few teeth attached. The jaw is hollow near the symphysis, as well as at the other extremity, as is seen by removing an upper fragment of the stone. When examined on its inner surface, a portion of the pterygoid or palatine bone may be seen very nearly in its natural position.

There are other portions of jaws with teeth, and, in one fragment, the base of a fractured tooth projects through the charcoal, which on close examination will be found to have its dentine convoluted as in *Lepidosteus* and *Archegosaurus* (see Pl. II. fig. 4). This tooth is larger than any others connected in these specimens with portions of the jaws.

The teeth, therefore, are of two kinds, but all appear to be more or less hollow. The smaller series do not seem to be either striated or convoluted externally, though there are some faint traces of folding at the base of the single detached tooth, specimen No. 30 (Pl. II. fig. 3). The larger teeth, one of which (specimen No. 17) was before mentioned, are very distinctly folded at the base, and present unequivocal Labyrinthodontic structure in having the dentinal substance

† The following notes are extracted by Sir C. Lyell, in compliance with the wishes of Dr. Wyman, from a longer and more special description of each of the numerous fragments of bone submitted to his examination.

‡ These numbers have reference to the series of specimens brought to England by Sir C. Lyell.

§ See note by Prof. Owen, p. 66.

convoluted, and processes of the pulp-cavity extending between the folds (see fig. 4).

The coexistence of two kinds of teeth above-mentioned is met with in both *Archegosaurus* and *Labyrinthodon* among Reptiles, and in *Lepidosteus* and other allied Ganoids among Fishes.

The minute teeth seen on the fractured edge of specimen No. 16, and on the surface of No. 22 (Pl. III. fig. 3), appear to be pharyngeal, but may nevertheless belong to the pterygoid or palatine bones; this last supposition is sustained by the fact that in specimen No. 16 a tooth of larger size coexists with the smaller ones, which would be less likely to occur among pharyngeals.

4. On the edge of specimen No. 8 is a well-preserved bone, enlarged at either extremity, resembling one of the bones of a reptilian fore-arm or leg.

5. Specimen No. 9 contains a strongly curved bone, nearly cylindrical in the centre, but which is quite broad and thin at either extremity. In its general shape it resembles the bone marked *b*, in the sketch of the pelvis of *Menobranchus* (Pl. II. fig. 8). This bone articulates in ichthyoid reptiles with the rib-like bone to which I have already compared No. 1, fig. 6, & fig. 8 *a*. According to Prof. Owen, both the bones here referred to, taken together, constitute the ilium or pleurapophysis.

6. With the above-mentioned bones occur numerous small scales, or bony plates, with indistinct concentric markings (see Pl. III. fig. 2), and also sculptured dermal or cranial bones of a larger size (specimen No. 4, Pl. II. fig. 5). The former are seen in specimens Nos. 1, 19, 22, 23, 25, 26; the latter, in specimens Nos. 4, 15, 16, 17, 18, and resemble the cranial bones of *Archegosaurus*, as well as those of some of the Ganoid fishes. These scales and plates respectively have such similarity of style as to render it probable that they belong to one individual.

7. To sum up the characters of the animal to which the above-described bones belonged, we may describe the head as having been covered with bony plates, the surface of which was distinctly sculptured. The teeth were of two kinds, a smaller series attached to the jaws, and a larger or folded series, which may have been attached either to jaws, pterygoids, palatines, or vomer. The coexistence of these two kinds of teeth is met with in Labyrinthodons and Ganoid Fishes.

If the bones marked Nos. 1 and 9 (see above, Notes 1 and 5), resembling *a* and *b*, fig. 8, Pl. II. (the iliac bones of *Menobranchus*), are true pelvic bones, then it becomes highly probable that the animal to which the above-described bones and teeth belonged was allied to Labyrinthodont reptiles.

8. All the fossil remains hitherto mentioned may have belonged to one individual between 2 and 3 feet in length; but on some of the same specimens of stone (Nos. 11, 12, and part of No. 1), there are several small biconcave vertebræ, usually more or less crushed, which seem to have formed part of a much smaller species, probably not more than 5 or 6 inches in length (see Pl. III. figs. 4 to 7). In the finest specimen, No. 12 (Pl. III. fig. 5), may be seen in one part a

connected series of nine, and in another a series of three of these vertebræ, all of an elongated shape. In the series of nine, the absence of spinous processes shows that the under surface is exposed,—also that they belong to either the dorsal or lumbar region. The transverse processes are largely developed, are broad at their bases, and contracted almost to a point at their free extremity (Pl. III. fig. 6). Imperfect traces of what appear to be ribs are visible near the third, sixth, and seventh vertebræ. In the series of three vertebræ, distinct articulating processes can be traced, in part from the fragments of bone, and in part from the casts in which they were lodged. In specimen No. 1, from which No. 12 was detached, may be seen casts of the under surface of the nine vertebræ, also some fragments of the series of three: traces of a spinal canal may be seen, if they are carefully examined in the direction of their length.

These elongated vertebræ, with hourglass-shaped bodies, well developed triangular transverse processes, and distinct articulating processes, all these characters being taken together, bear closer resemblance to the conditions of Salamanders and Ichthyoid Reptiles than to Fishes. The biconcave vertebræ, though they are to be met with in some Salamanders, yet are more confined among reptiles to the ichthyoid species.

No vertebræ, ribs, or spinous processes which could be referable to the larger animal before described have been found.

NOTES *on the above-described* FOSSIL REMAINS. By Prof. OWEN, F.R.S., G.S. &c.

HAVING, in compliance with the request of Dr. Wyman, examined and compared the subjects of his Memoirs, the results of such comparisons, agreeably with his desire, are here subjoined.

Pl. II. fig. 6. The bone, specimen No. 1, most resembles the proximal or upper element of the iliac bone of the *Menopoma*: it may have an equal or perhaps closer resemblance to that of the *Menobranchus*, but the skeleton of this perennibranchiate batrachian does not exist in the Museum of the College of Surgeons, or in the British Museum.

Pl. II. fig. 7. The bone, No. 2, so far as the fractured surface permits the comparison to be made, accords best with the humerus of the *Menobranchus*. It shows the same sub-bicondyloid distal end, and the characteristic deltoid and pectoral plates or crests near the proximal end. It has nearly the same proportion to No. 1 which the humerus bears to the upper element of the ilium in the *Menopoma*. Near the distal end of No. 2 is the articular end of a smaller bone, fig. 7 *a*, corresponding in size and shape with the head of the radius in the Menopome.

Pl. II. fig. 5. The flat bone* (No. 4), with a slight convexity on the sculptured surface, and a slighter concavity on the opposite smooth surface, resembles in the character of the sculptured surface some of the broad and flat cranial bones of *Labyrinthodon*. The deep radiating grooves, at the peripheral part of the bone, give the appear-

* See Note 6 of Prof. Wyman's Observations, p. 65.

ance of rays; but this appearance seems to be due to the abrasion or removal of the very thin parts of the bone impressed by the grooves, the thicker raised interspaces being left.

No. 9 shows the half-twist characteristic of the bone (lower or distal element of the ilium) alluded to by Dr. Wyman (see above, p. 65, No. 5), which character, however, is manifested by most of the long bones of the *Menopoma*. In reference, however, to the bone in the hyoid arch of Ganoid fishes, to which this and other of the long bones in the fossil in question have been compared, I would remark, that the half-twisted character is not present in the cerato-hyal, or other element of the hyoid apparatus, in the *Lepidosteus*, approaching in shape to any of the long bones of the fossil: and I would further remark, that the sum of the evidences afforded by the several remains agrees best with the characters derived from the skeletons of the perennibranchiate Batrachians. Although a single bone, amongst the series obtained from the Nova-Scotian coal-tree, may show some resemblance to the cerato-hyal of a *Lepidosteus* or *Amia*, the characters of all the other fossil bones accord closer with those of the above-cited batrachian skeletons, and do not repeat the characters of any bone in the known existing ganoid and salamandroid fishes. Had the fossil bones found in the coal-tree belonged to a ganoid fish, although one pair —the cerato-hyals—might have resembled certain long bones of a batrachian, those of the rest of the skeleton would have offered unmistakeable piscine characters, whilst these are not shown by any of the bones extracted from the coal-tree.

P.S. [March 9, 1853.]—Although the long bones have been compared by Dr. Wyman and myself to those in the skeletons of existing Perennibranchians, it is not improbable that the corresponding bones in the *Archegosaurus* and *Labyrinthodon* would present similar correspondences: and the sculptured surface of No. 4 (Pl. II. fig. 5) offers significant evidence of the closer affinity of the Nova-Scotian coal-field reptile to those that have been discovered in formations of corresponding age in Europe. The reptile or batrachian in question cannot be referred to any known species of *Archegosaurus* or *Labyrinthodon*; and, it having been suggested that it would be convenient to the geologist to have a provisional name for this fossil, that of *Dendrerpeton Acadianum* is proposed: the generic name having reference to the peculiar circumstances under which the fossil reptile was found, and the specific name indicating the geographical position of the coal-field,—*Acadia* being the ancient Indian name of Nova Scotia.

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2. *Notice of a* BATRACHOID FOSSIL *in* BRITISH COAL-SHALE. By Professor OWEN, F.R.S., G.S. &c.

[PLATE II.]

WHILST in the museum of the Earl of Enniskillen, during a visit at Florence Court, after the Belfast Meeting of the British Association, September 1852, my attention was called by Prof. M'Coy to a coal-shale fossil in a drawer of unnamed and unarranged specimens,

which the practised eye of the Professor discerned to present more the characters of a Reptile than of a Fish; and, after a careful scrutiny, I became satisfied that the Professor's surmise was correct, and that the specimen in question presented closer marks of resemblance to the *Archegosaurus* * than to any known species of fish from the Carboniferous series. At Prof. M'Coy's request, and with the liberal permission of Lord Enniskillen, I brought away the specimen for more detailed comparison with the skeletons of recent *Reptilia*, and with the fossils and casts of extinct species, available for the purpose, in the Metropolitan Collections; and I now submit to the Geological Society the specimen itself with the results of these comparisons.

The specimen (Pl. II. fig. 1) consists of the right half of the facial part of the skull, with the short premaxillary (22), long maxillary (21), and broad malar (26) and lacrymal (73), with part of the postfrontal (12) and squamosal (27) bones, slightly dislocated and squeezed into the shale, with their smooth inner surfaces exposed. A part of the shale from which the bone has been removed shows the impressions of the reticularly sculptured outer surface of the bones. The premaxillary contained a few teeth, longer than those of the maxillary: of these teeth one remains *in situ* and there is the impression of a second.

The maxillary, of the alveolar border of which upwards of three inches are preserved, contains about 30 teeth, of small and subequal size; implanted in sockets; conical, pointed, very slightly recurved, presenting, most of them, the oblique aperture of a cavity, on the inner side of their base, which side is the one exposed to view, owing to the position in which the skull is imbedded. The height of the maxillary is greatest about one-fourth from the maxillo-premaxillary suture; thence it diminishes in height, at first rapidly, afterwards gradually, terminating in a point far behind the orbit, as in the *Labyrinthodon* †: the inner surface of the maxillary presents a longitudinal ridge running parallel with the alveolar border, about 3 lines above it, for an extent equal to the middle third part of the alveolar border, which ridge forms the partial wall of a smooth canal or groove, answering to the air-passage leading from the nostril in the *Labyrinthodon*. A portion of the anterior part of the left maxillary bone lies obliquely and partially across the exposed inner surface of the left maxillary. The portions of bones that seem best to answer to the lacrymal and malar in the *Archegosaurus* and *Labyrinthodon*, are those which together constitute the inferior border of the large orbit. The portions of the bones which best correspond with the postfrontal and squamosal in the above-cited Batrachoid reptiles, show by their breadth that the outer surface of the suborbital and postorbital parts of the skull has been as completely ossified, or encased in bone, as in these Reptiles. The indications of the sculpturing of the outer surface of the cranial bones, afforded,

* Beiträge zur vorweltlichen Fauna des Steinkohlengebirges, von Dr. Goldfuss, 4to, 1847.

† Owen, Geol. Trans. 2nd Ser. vol. vi. pp. 503–543, 1841; and Burmeister, Die Labyrinthodonten aus dem Bunten Sandstein von Bernburg†; 4to, 1849.

as above mentioned, by the impression upon the shale-matrix, agree more with the finer reticulations characteristic of the cranial bones of the *Archegosaurus Dechenii* * than with the deeper and stronger reticulated markings of the same bones in the *Labyrinthodon*. The Comparative Anatomist and Palæontologist who may have been occupied with the special researches required for the determination of the actual nature and affinities of the fossils from the Steinkohlengebirge of Germany, described by Prof. Goldfuss, under the generic title of *Archegosaurus*, and deemed by the same learned and painstaking investigator to make a transition from Fishes to Lizards and Crocodiles†, will have no difficulty or hesitation in recognizing in the characters of the coal-shale fossil in Lord Enniskillen's collection, as above interpreted, those of a vertebrate animal most nearly allied to the *Archegosaurus*. Those characters are not reconcileable with any cranial structure of the most sauroid, or rather salamandroid, fossil fishes hitherto described. With regard to the affinities of the *Archegosaurus* of the German coal-fields, of which a large proportion of the skeleton has been obtained, I retain the same opinion which I formed, after becoming acquainted with the estimable work of Prof. Goldfuss, and after receiving from its author casts of the fossils therein described and figured;—viz. that they were essentially Batrachian, and most nearly allied to the perennibranchiate, or lowest or most fish-like of that Order of Reptiles. The evidence which Sir Charles Lyell has obtained in corroboration of that afforded by footprints, of the existence of *Reptilia* in the coal-formations of Nova Scotia, leads also to a reference of these coal-field Reptiles to the same low group in the air-breathing vertebrate classes.

The fossil, above described, gives additional evidence to the same purport, and extends the known geographical range of the Batrachoid Reptilia of the Carboniferous epoch. That it belongs to the period of the coal-formation is shown by the nature of the matrix in which it is imbedded; the slab of coal-shale containing, besides the fossil in question, the large scale of a *Holoptychius*. This gives the evidence of chief import in the great question of the geological age of air-breathing Vertebrata. As to the precise locality from which the portion of coal-shale and its fossils was obtained, the noble owner of the unique specimen testifies that during the period including the acquisition of that specimen, no fossils from extra-Britannic coal-formations had been added to the collection at Florence Court, and his lordship's conviction, from memory, is, that the specimen was obtained, by purchase, from a dealer, with other fossils from the Glasgow coal-field, at Carluke, Lanark; that the other fossils, so obtained, being of recognizable carboniferous Fishes, were labelled and placed in their proper drawers; whilst this small and ambiguous specimen was placed temporarily in a drawer assigned for such miscellaneous objects.

In conclusion, I beg to repeat, that to Prof. M'Coy belongs all the

* *Op. cit.* pl. 1. fig. 1.

† *Ib.* "Fossile Saurier u. s. w. die den Uebergang der Ichthyodeen zu den Lacerten und Krokodilen bilden," p. 3.

merit of having first detected the reptilian nature of the subject of the present communication.

DESCRIPTION OF THE FIGURE.

Plate II. Fig. 1. Portion of a skull of the *Parabatrachus Colei*, a Batrachoid fossil allied to *Archegosaurus*.

12. Postfrontal.	26. Malar.
21. Maxillary.	27. Squamosal.
22. Premaxillary.	73. Lacrymal.

February 2, 1853.

The following communications were read:—

1. *On the* Geology *of a Portion of the* Himalaya Mountains *near* Subathoo. By Major Vicary.

[Communicated by Sir R. I. Murchison, F.G.S.]

The section which accompanies this paper is an approximation drawn up partly from memory, and in part from my notes. The line is taken in a general way in a direction from S.W. to N.E., and does not pretend to be very exact. Having thus premised, I shall attempt to describe the rock formations, starting from the most recent, viz. the Siwalic Range of hills.

No. 1 of the Section marks the old beach of the Tertiary sea which formerly covered North-Western India, and is composed of a thick bed of rounded water-worn boulders, which gradually thin off towards the plains. No. 2 is the Siwalic Range of sandstone hills (Miocene?) so ably described and illustrated by Falconer and Cautley in their 'Fauna Antiqua Sivalensis.' I may here add, that the same sandstone is prolonged in a north-westerly direction *viâ* Kote-Kangra to and beyond Jumboo, and in that direction occupies a much greater superficial area, extending even to the old Fort of Rotas on the road from Jelum to Attock.

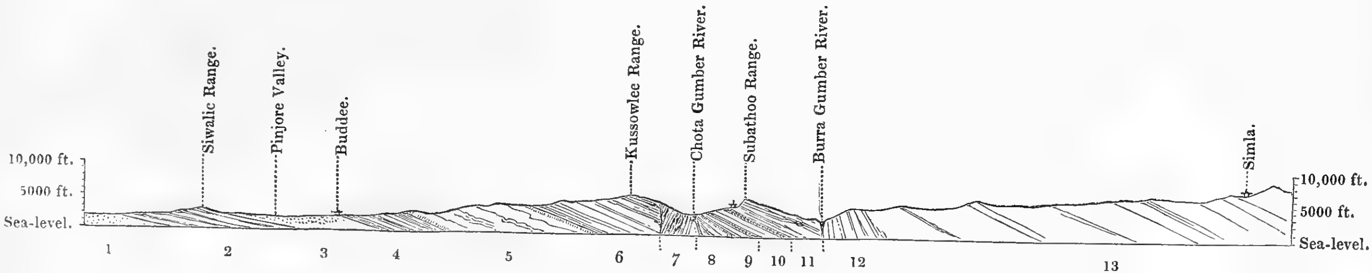
The Pinjore Valley (No. 3), like that of Deyrah Dhoon, is filled to a great depth with rounded water-worn boulders, beneath which the Siwalic beds are masked. At Buddee, sandstone (No. 4), not unlike that of the Siwalics, appears at the surface, but I have never found fossils in it, and all connection with the Siwalic beds is concealed beneath the boulders of the Pinjore Valley. Hence rise the lower and outer hills of the Himalayas. At No. 5 of the Section we meet confused strata of variegated shales, the prevailing colour being red and yellow: I was unable to detect fossils of any kind in them.

The Kussowlee Range, No. 6.—I have traces of *Turritella* in some calcareous sandstone beds near the crest of the range, and the rocks in many places appear to have been subjected to the action of heat, though I was unable to detect any igneous rock.

No. 7.—Descending from this range into the valley of the Chota Gumber river, and about four miles short of it, a section formed by a watercourse, running at right angles to the range, is exposed, exhibiting

General Section from the Plains of India, across the Kussowlee and Subathoo Ranges, towards the Simla Range.

(Scale 5 miles to the inch.)



1. Boulders and gravel; old beach.
2. Sandstone of the Siwalics.
3. Boulders and gravel.
4. Sandstone. No fossils.
5. Red and variegated shales, in confused strata. No fossils.
6. Sandstone, &c., *Turritellæ* near the top.
7. Red shales and gypsum, sandstone with *Algæ*?, and blue shales and limestone bands, with *Astarte*, *Turritellæ*, &c., and Bones.
8. Shales, similar to those of No. 5. No fossils.
9. Blue shales, with *Astarte* and *Turritella*, overlaid by Nummulitic beds.
10. Blue shales, with *Astarte*, &c., overlaid by Nummulitic beds.
11. Blue shales, with *Astarte*, &c., and Bones, red shales with limestone bands, and red shales (containing Bones) with sandstone beds.
12. Dark slates and coarse limestone, vertical. No fossils.
13. Slates and coarse limestone beds. No fossils.

beds inclined 60–70° to the west, with a north and south strike (nearly), composed of red shales thick bedded, with bands of gypsum; then a bed of sandstone about 20 feet thick, full of cylindrical forms not unlike the stems of the larger Algæ; then blue shales abounding with *Astarte*, *Turritella*, and many other forms not yet identified: I also detected some fossil bones in this bed. Following this watercourse towards the Chota Gumber river (and towards Subathoo), thick beds of the same shales are met with, red and blue, separated by bands of impure limestone, containing the same species of fossils, and occasionally fossil bones well-preserved, but very difficult to extricate, owing to the hardness of the rock. It was in these limestones that I first detected Saurian bones in 1847. These, and all the beds in the valley of the Gumber river, are in great confusion, following no general arrangement, often perpendicular, or even inclined to the west—overthrown in fact.

Nos. 8, 9, 10, & 11 of Section.—Crossing the Chota Gumber river at the base of the Subathoo range we find variegated shales, No. 8, in all respects similar to those of No. 5, and without fossils. Continuing the ascent towards Subathoo we soon come upon soft crumbling blue shales, containing *Astarte* and *Turritella* in abundance, the beds dipping to the south-east. Higher up the hill the first nummulitic bed crops out, and is about 80 feet in thickness. Still ascending, the same bluish shales are repeated, with *Astarte*, &c., having a thickness of about 600 feet; and here a second bed of nummulitic rock is found, about 50 feet in thickness. These nummulitic beds are usually of a soft yellowish rock, passing into blue or bluish-grey in the more solid parts. The Nummulites abound, but there are also other fossils accompanying them, of which I was unable to obtain a perfect specimen. Above this bed the blue shales with *Astarte*, &c., are again found, and containing also fossil bones. These beds, alternating with the red shales and bands of limestone, continue up to the Military Station of Subathoo; hence to the top of the hill above Subathoo, and about 800 feet higher, thick beds of red shales occur, with alternating beds of a hard blue-tinged siliceous sandstone,—all dipping at about 30° to the S.E. The red shales contain fossil bones, the sandstones nothing; the latter, from their hardness and solidity, resist the disintegration which so rapidly affects the shales, and stand out in strong relief from the south-western escarpment of this range of hills. From the heights near Kussowlee I was able to trace these siliceous sandstone bands as far to the southward as Nahn, upwards of seventy miles, accompanied by the same red shales; and though it was not in my power to visit the whole of this line to the southward, I can with safety state that the formation is in all respects the same, and identical with that of Subathoo. I followed the nummulitic beds for about thirty miles trending nearly north and south, and holding the same character. Beds of limestone are found amongst the blue shales, which, in fact, pass gradually into them, and the fossils in both are alike. The blue shale on which the Quarter-guard of Subathoo stands contains fossil bones in abundance; but the bones are ill-preserved, and it is most difficult to obtain any

in a state fit for identification. Saurian remains are, however, plentiful; I am not so sure with respect to Mammalian remains, but as the specimens are in good hands, I hope soon to settle that point.

Crossing the ridge of the Subathoo Range, and moving down the north-eastern slope to the lower road to Bojh, the red and blue shales are again met with, and in a cutting to form the road I detected some fine Saurian fossils in red shale; this place is about 800 feet lower than the Nummulite beds at Subathoo, and from their dip I hoped to have met with them, but though I found the shales with their peculiar fossils, I found not a trace of the Nummulites; neither was an attentive examination of the hills for eight miles farther to the south-east more successful. I was unable to examine farther in the line of the dip, but I may mention that a prolongation of this line would leave Simla eighty miles (or more) to the left, and that in moving towards Simla from the most northern portion of the Nummulite beds visited by me, viz. from the village of Kukkurhuttee near the Iron Bridge, by which the road from Subathoo to Simla crosses the Burra Gumber River, a fault of great magnitude is met with, and the Gumber at that point finds its way at a low level (about 2000 feet above the sea) through it. The fine section exposed at this place exhibits a precipitous face of dark slates and coarse limestone (No. 12) with vertical beds, and devoid of fossils. From hence to Simla, eighteen miles, we pass over hills of shales and slates with coarse limestone beds (No. 13), and Simla itself is for the most part made up of clay-slates and rude limestone beds: in all this line of country there is not a fossiliferous rock.

It is interesting to observe the progress so rapidly being made in our geological knowledge of the Himalayas, and the discovery of Tertiary formations at very distant points along the range, on the westerly slopes. We are now acquainted with two places, remote from each other, where *sure* Nummulitic Tertiaries are found; viz. far to the southward at Chirra-Poonjee, long known from its fossils, published by Dr. M'Clelland in the Calcutta Journal of the Asiatic Society of Bengal, and at Subathoo. The former place has lately been visited by Mr. Oldham, Geological Surveyor in Bengal, whose valuable observations have set all doubt at rest; he assures us that the rocks of Chirra-Poonjee with their fossils are undoubtedly Tertiary, a fact long suspected by Indian geologists. A specimen from this vicinity kindly given to me by Dr. Hooker, the adventurous and able explorer of Sikkim, is a grey limestone full of Nummulites; in mineralogical structure and fossils it strongly resembles the harder class of Scinde nummulitic rocks. It is to be hoped, now that a *sure* geological horizon has been fixed on the westerly slopes of the Himalayas, that our geological knowledge of these mountains will steadily progress. I regret that ill-health and causes beyond my control compelled me to leave India, and prevented me from following up my own observations near Subathoo with more useful effect.

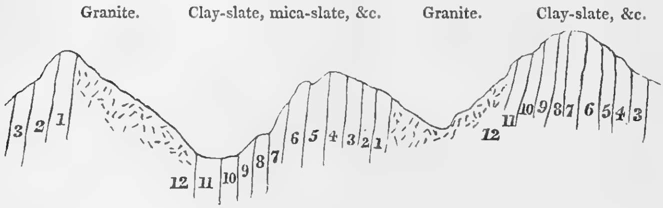
2. *On the* Gold Fields *of* Victoria *or* Port Philip.

By G. H. Wathen, Esq., Mining Engineer.

[Communicated by P. N. Johnson, Esq., F.G.S.]

General Description, Geographical and Geological.—A chain of mountains, or rather a series of distinct ranges, runs round the south-eastern corner of Australia, nearly parallel to the coast line, and from fifty to eighty miles from the sea, forming part of the main chain of the continent, and rising at its highest summit, Mount Kosciusko, to 6500 feet above the sea-level. This mountain chain in Victoria consists of clay-slates, mica-slates, and flinty slates, in successive steps, forming collectively a recurring series somewhat thus—

Fig. 1.—*Diagram showing a Section through Hills in the Australian Pyrenees.*



The slates are nearly or quite vertical, with a north and south strike, and are intersected by numerous quartz-veins, running at an acute angle with the slates. Vast plains of trap, forming high table-lands, run up to the base of the mountains and probably cover their lower slopes. It is in the valleys and gullies of these mountains, and not very far from their junction with the trappean plains, that the rich deposits of gold are found. The auriferous districts are commonly broken by deep valleys and precipitous steeps. The hills are thickly forested; the soil poor and gravelly, and the surface strewn with angular fragments of white quartz.

Gold-fields.—Gold has been found at several points remote from each other along this zone of mountains; but incomparably the richest deposits hitherto opened in the Colony of Victoria, and indeed in the entire continent, are those of Ballarat and Mount Alexander, the latter far exceeding the former in extent and richness, while even the former is said by Californian miners to surpass in richness and yield all that they have witnessed in that region of gold.

Mount Alexander gold-field.—Mount Alexander lies in latitude 37° South, longitude 144° 20′ East, and is about 75 miles north-west of Melbourne. It was named by the first explorers Mount Byng, and is thus distinguished in many maps. It is a rocky granitic mountain, with a rugged flattened outline, towering some hundreds of feet above the summits of the forested ranges of slate-rocks which surround it, and of which it is the centre and nucleus.

The enormous amount of gold which this district has yielded has

chiefly been derived from two valleys with their lateral gullies and ravines. These valleys are known by the names of the streams or "creeks" that run through them. One of these, Forest Creek, takes its rise in Mount Alexander itself; the other, Fryer's Creek, has its source in the high and broken ranges of slate that environ the Mount. Both Creeks are tributaries of the River Loddon. The workings extend five or six miles along the valley of Fryer's Creek, and about ten along that of Forest Creek. At Fryer's Creek gold has been found in large quantities beneath the bed of the stream, near its source, in the upland gullies. Forest Creek, on the contrary, appears to grow barren as it approaches the higher granite country, where it originates. On the banks of the River Loddon gold is found in small quantities, lodged in the crevices of the rocks, but no large deposits have been met with on the river, and even the stream into which Forest Creek runs, though itself only a feeder of the Loddon, proves far less rich than Forest Creek and its mountain affluents. In short, it would seem that the gold had been arrested in the small mountain ravines and gullies, and was never washed down to the large streams. Auriferous sands on river-banks or in alluvial plains are unknown in the Colony. When within 12 inches of the surface, the gold is disseminated in a quartzose gravel; when found at lower depths, it is almost always imbedded in clay, usually of a very tenacious kind.

Ballarat gold-field.—The Ballarat gold-field, which is about fifty-five miles north-west of Geelong and Port Philip Bay, lies at the junction of the slates with the trappean country, about seven miles from an extinct and now forest-grown volcano, known as Mount Boninyong. A second similar black volcanic mount rises out of the slate ranges, about ten miles due north of Boninyong. Granite crops out in small patches between the two Mounts.

This auriferous tract is united to that of Mount Alexander by a succession of similar dark forested ranges, rough, rocky, and sterile, strewn over with quartz, and consisting of the same series of micaceous, flinty, and clay-slates.

Volcanic tract.—At the western base of these sombre hills lies a large tract of the most fertile and beautiful country—the garden of Australia Felix,—the rich soil of which is the product of decomposed lava. These park-like plains, sprinkled over with groups of trees, are diversified by numerous domelike lava hills, without trees, but of the richest verdure. I have counted no less than 24 of these remarkable bold hills from the summit of one of them. The south and east sides are commonly steeper than the others. They are usually flat at the top; but in one of them, which I named Mount Lyell after the illustrious geologist, there is a small crater, which had the reputation of being fathomless, but which I found to be in fact about 50 feet deep, consisting of an upper cup or crater about 15 feet in diameter, contracting below into a narrow rocky shaft or well, 30 feet deep and 3 or 4 wide. The freshness of the traces of the flow of the lava, which is of a soft and perishable kind, indicates that the epoch of igneous action cannot be very remote. Altogether

this volcanic region forms a most interesting subject for geological research and speculation.

Quartz veins.—The sedimentary rocks are traversed by numerous veins of quartz, about 3 feet wide, of unknown length, in some districts descending to an unknown depth, in others not more than 3 or 4 feet deep. These veins or dykes run N. and S., or N.N.E. and S.S.W., and always make an acute angle with the laminæ of the slates. They seem to be the original matrix of all the gold found in the valleys and creeks. The quartz is often intersected by many joints and narrow fissures, filled with a red ferruginous earth, in which particles of gold are disseminated. Gold is also found implanted in the quartz itself, and attached to the sides of its cavities. These auriferous veins were discovered and wrought before the alluvial gold deposits or "Diggings;" and as they were worked with profit by the rude means at the command of the untrained diggers, they would doubtless well repay those who may operate upon them with all the appliances of modern European mining, so soon as the existing social excitement shall have subsided and wages shall have fallen from their present extravagant height. The first gold-working in the Colony was on a quartz vein running through one of the trappean plains so common in this country. The auriferous quartz is not milk-white, but has a delicate yellowish colour, and a waxy lustre. That which is much broken and fissured appears richer than the more hard and solid. Sometimes large boulders of quartz are found deep beneath the surface, in the midst of auriferous clay; but it is remarkable that in such cases the quartz boulders rarely or never contain gold, however rich the clay it lies in may be.

These quartz veins appear, as already said, to be the original seat and matrix of the gold. The slate rocks having undergone continual degradation during the lapse of ages, the quartz-veins also have suffered decay and disintegration when their enclosing walls no longer existed; the joints and fissures in the veins of course aiding the destructive process. Hence the gold disseminated in their mass became liberated, and, together with the materials of the quartz veins and slate rocks, were washed down into the gullies and creeks, where the latter formed the beds of clay, gravel, &c., now found in these depressions; whilst the particles, grains, and nuggets (or pepites) of the precious metal by their own weight descended to the lowest of the permeable beds and into the chinks and cavities of the slate rocks beneath, forming the "pockets" of the miners.

Mode in which the Gold is deposited.—Occasionally the gold grains are seen strewn on the top of the soil. Sometimes they lie 30 feet beneath the surface, and may also be met with in other localities at every intermediate depth. The "Diggings" may however be conveniently classed into two divisions: first, "Surface Workings;" second, "Pit" or "Hole Workings." In the first the gold is either found lying on the surface or (much more commonly) is diffused through the gravelly soil to the depth of 6 or 12 inches, beneath which is usually a stiff red clay containing little or no gold. These

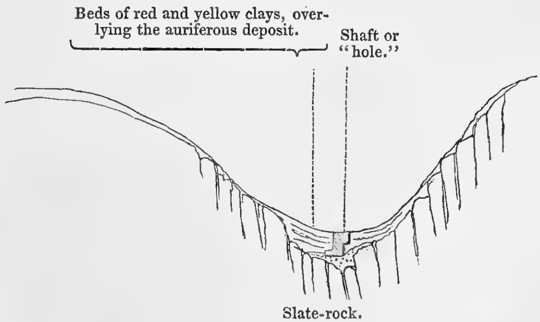
deposits are commonly on the sides and crests of hills adjoining rich gullies. The second or deeper class of workings consists of pits or "holes" from 3 or 4 to 25 and even 30 feet deep. In these deposits the gold is almost always imbedded in a stiff clay. When any spot is rich on the surface no gold will be found immediately beneath, and *vice versâ* when rich below it will yield nothing on the surface.

These deeper or Pit Workings are of three kinds:—

1. In the channel of an auriferous creek, at points where the stream is impeded by bars of vertical slates traversing the valley, gold is often found by sinking through the alluvial mud and earth down to the rocky channel beneath. Here the gold is lodged in a grey clay, which fills the chinks and fissures of the slate rock, whence the miners extract it by means of knives, spoons, shears, or any other tool they can meet with. Where the bed of the stream expands into an alluvial flat, the auriferous deposit will also increase in width. Such was the first-worked "Golden Point" of Mount Alexander, a local expansion of the bed of Forest Creek. If it should happen that the existing Creek has left its original channel, the run of the gold deposit then quits the modern Creek and follows its ancient channel. These workings in the beds of creeks are commonly from 3 to 10 feet deep. They were the first undertaken at Mount Alexander. The deposits are richest at points where the stream has been impeded in its course, either by frequent sinuosities or by being crossed by a bar of slate as already mentioned.

2. A second kind of deep auriferous deposit is met with in the dry gullies which descend from the higher ranges to the main valleys, generally with a gentle inclination, from a quarter of a mile to a mile in length. These gullies in some spots are narrowed by the converging hills and sometimes expand into open slopes or flats. Here

Fig. 2.—*Section through a Gully, showing the ordinary width of the Auriferous Deposit.*

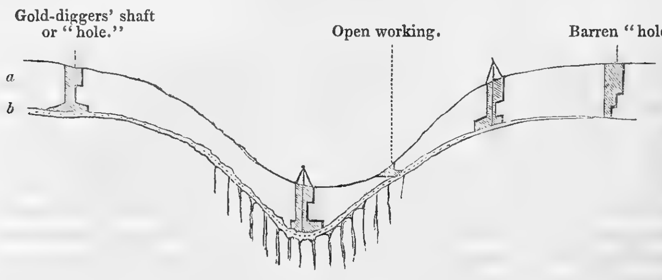


the gold is commonly found, at from 10 to 20 feet beneath the surface, in a reddish or yellowish clay, lying either upon the fundamental rocks, in the chinks of the vertical slate, or else upon a thick tenacious

white or yellow clay, known by the miners as "the Pipe Clay." This is sometimes of unknown depth, and sometimes passes imperceptibly into the vertical laminæ of soft micaceous slate. In some of these gullies there is a continuous line of workings half a mile in length. The richest deposit is always found in what appears to be the *ancient channel* or bed of the gully, where the opposite slopes of the rocky gully meet deep beneath the overlying strata of gravel and clay. The breadth of the area which yields gold is usually not more than a few feet, rarely if ever more than a few yards. The superior strata clearly owe their origin to running water. They differ much in composition in different localities. They may be hard or soft—may consist of tenacious clay or of sandy gravel. When first turned up they almost always are of some bright hue of red, yellow, or white; but this soon fades away on exposure to the air. It is remarkable, that these gullies are, with scarcely an exception, on the south side only of the valley.

3. The third kind of deep workings are those on the sides and crests of the low rounded hills or acclivities at the sides of the auriferous gullies. It often happens that the width of an auriferous gully is contracted before it falls into the main valley by spurs from the lateral hills, which, protruding from either side, form a kind of gateway to the gully. In such localities the gold deposit was found to continue across the gully up to the foot of these enclosing hills, and thence up their sides to the rounded crest, where the rich field commonly ceases. In the gully below, the gold-bearing deposit may be at a considerable depth. At the crest of the hill it will also be deep; but intermediately, at the foot of the hill, the "holes" will be perhaps only 2 or 3 feet deep, or the gold may in this intervening space be scattered in the surface gravel; so that a section through the hill and gully below would exhibit the gold deposit somewhat thus—fig. 3.

Fig. 3.—*Section through an Auriferous Gully and contiguous Hills.*



a. Alluvial clays, red, yellow, and white, in irregular beds.
b. Auriferous deposit. *c*. Slate-rock.

The alluvial strata on the sides and tops of these hills have a general conformity to the present surface, but are extremely irregu-

lar, so that two pits, a few yards apart, may present two totally different sections; as though the beds had been deposited by means of strong conflicting eddies and currents. They consist sometimes of stiff red and yellow clays, like those in the gullies; but there also frequently occur beds of a very hard reddish concrete, composed of quartz and slate pebbles. At Ballarat large boulders of quartz, 2 or 3 feet in diameter, were found imbedded in the auriferous clays, and, more rarely, detached masses of a conglomerate of fragments of lava, trap, and quartz, imbedding rounded pieces of gold. At these workings the rich "pockets" of gold were commonly associated with a bluish clay, running in irregular veins and patches. So rich was this clay, that 9 lbs. weight of gold have been taken from a single tin-dishful of it, about 14 inches in diameter and 5 or 6 inches deep.

Enormous amounts of gold have been taken from some of these rounded alluvial hills. The yield, however, is not so uniform as in the gullies; a rich spot and a barren may often lie close together. In these deposits, as in those of the dry gullies, the gold is usually imbedded in red or yellow clays, lying immediately on the fundamental slates, or on the "pipe-clay." When the gold-yielding clay lies on the rock, small lumps or nuggets of gold will sometimes slip down between the vertical slates.

In conclusion, the methods of separating the gold from the gravels and clays are the same as those used elsewhere in New South Wales and California, and vary of course according to the means at the command of the miners*.

February 23, 1853.

James Bright, Esq., M.D., David Forbes, Esq., and Joachim Otté, Esq., were elected Fellows.

The following communications were read:—

1. *On the* Skin *of the* Ichthyosaurus. By Henry Coles, Esq., F.G.S.

[Plate V.]

Some years ago, I had the opportunity of collecting a number of Saurian remains from the Lias quarries on the line of road between Tewkesbury and Upton-upon-Severn; but, not having leisure at that time to arrange them, I packed them up without cleaning, hoping I might be able hereafter to examine them more thoroughly and carefully. About eighteen months since, when scraping the clay from a vertebra of one of these *Ichthyosauri*, I noticed a number of minute black points. On looking at them through a microscope, I was much struck by their resemblance in form to teeth; and, on placing a fragment of the layer of carbonaceous-looking matter with which the vertebra was partially invested, under the microscope, it appeared

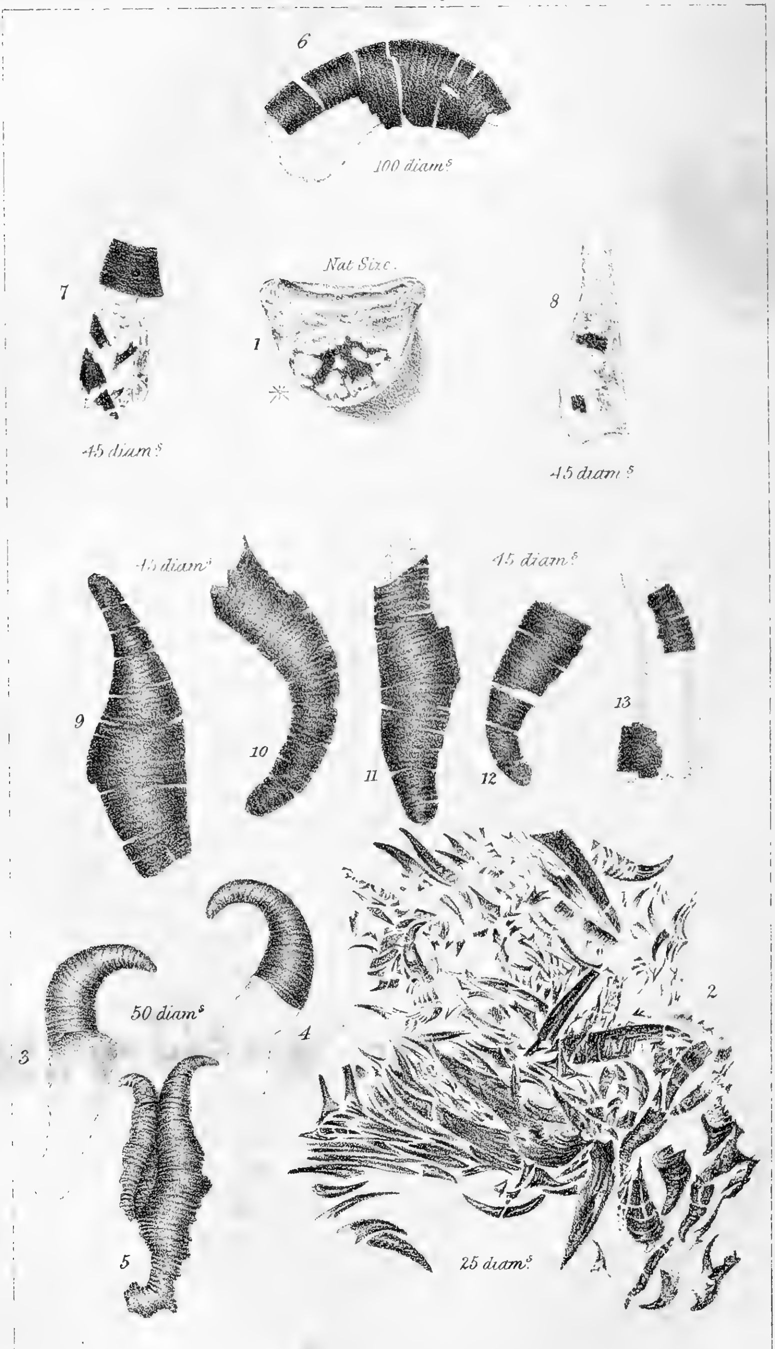
* [Besides the Ballarat and Mount Alexander gold-fields, "diggings" have been opened at Mount Blackwood and on the Moorabool River, near Ballarat; on the Plenty and the Yarra Yarra Rivers, N.E. of Melbourne; on the Mitta Mitta River and Lake Omeo, in the N.E. part of the Colony; as well as at several points along the eastern portion of the Boundary-line between Victoria and New South Wales. —Ed.]

like a portion of the "bone bed" found at the base of the Lias at Coombe Hill. Shortly after this, I happened to be in the garden of a fossil collector at Cheltenham, where there was a mass of Saurian bones which had been for several months exposed to the weather, and in the crevices of which, a black kind of matter had apparently collected. Under the microscope, this appeared precisely similar to that which I had noticed in my specimen. Owing to absence from England and other circumstances, it was long before I had the opportunity of examining my other specimens. On doing so, I found I had portions of three individual *Ichthyosauri* which exhibited the same appearances. Some of the bones had a partial investment of this substance, resembling in colour and thickness a coating of black cloth. As I knew no one who had such an extensive and accurate knowledge of minute organisms as Professor Quekett of the London College of Surgeons, I forwarded some fragments to him, merely stating that "they were found on cleaning fossils." As he had never seen such like before, and having only small detached fragments for examination, he could not at first give a decided opinion upon them; but upon my submitting to him more perfect specimens, and giving him an account of how they were procured, his opinion fully coincided with mine, that they had formed a part of the integument of the *Ichthyosaurus*. Through his kindness, I have had some of the specimens delineated by one of the practised artists employed at the College of Surgeons. (See Plate V.) The outlines have been carefully and accurately traced by means of the camera lucida, and an inspection of the figures will give a better notion of the forms of the minute bodies composing the carbonaceous layer, and of their relative size, than any description could convey.

In the best preserved specimens, this thin layer of black substance (which appears to be all that remains of the skin, and was possibly its external portion) consists of these minute bodies confusedly massed or felted together in the interior of its substance, whilst on its external surface they are more free and separate, and exhibit the largest forms. In such specimens it is very difficult to detach them singly, and I have been able only to get them isolated when they have been separated from the mass and disseminated through the surrounding sand and clay, and it is in such cases that the broken-off points exhibit the tooth-like appearance above alluded to. When grouped together on the surface, they appear like hairs or spines; but when detached, by their short and generally flattened shapes, they approximate more nearly to scales.

As regards their structure, each of these minute bodies is composed of a cortical and medullary? portion. The present condition of the cortical portion is a black, opaque, carbonaceous substance, which appears to have been originally a hollow body, and by subsequent infiltration, carbonate of lime seems to have formed what may be called its medullary portion or core. (See Pl. V. figs. 6, 7, 8, &c.) This last is soluble, with effervescence, in dilute acids, while the former is unaffected by these agents, or by liquor potassæ.

Whether, therefore, these bodies should be classed with spines, hairs, or scales, it might be difficult to determine, and indeed there



Lens Aldous, del. et lith.

Day & Son, Lith^rs to The Queen

SKIN OF ICHTHYOSAURUS

are as many points of dissimilarity as of resemblance to any of these structures. From the great approximation of the *Ichthyosaurus* to the Ichthyic form, as particularly evidenced in its general contour and its biconcave vertebræ, it need be no matter of surprise to find a structure analogous to scales in this animal. And when we regard the strange and anomalous coverings of the Fishes of the Palæozoic period, we might be led to expect that even in animals of a later æra, there should be a great departure from ordinary types, and a blending together of the peculiarities of diverse structures. Although, then, none of the usual tegumentary appellations seem to me strictly applicable, I am not disposed to offer another to the overburthened list of scientific names, but would prefer calling these bodies *setiform or bristly scales.*

I am not able to offer any satisfactory conjecture as to what was the real condition and complete structure of the integument of the living animal. The brief notices by Dr. Buckland and Professor Owen†, with the slight addition to our knowledge on the subject which this paper professes to offer, leave much further information to be desired, and a large scope for future research.

In two uncleaned masses of the bones of *Plesiosauri,* I have not succeeded in detecting any analogous structure.

I have been rather diffuse in the detail of the circumstances attendant on the discovery and identification of these minute structures, partly because I wished to obviate any conjecture that they might be merely accidental extraneous bodies, and partly because they furnish an instance of the importance of not overlooking apparently insignificant objects, and suggest an argument for the more minute investigation of the material in which fossils are found imbedded.

I may add, that by the courtesy of Mr. Waterhouse, of the British Museum, I inspected, with him, many Saurian bones in that Institution, but we found they had been so well cleaned that no traces of the skin could be discerned. I met with no better success among the large specimens in our own Museum, but in a small *Ichthyosaurus* from Lyme Regis, presented by Sir H. De la Beche, a considerable portion of the skin exhibiting these peculiarities has been preserved.

Mr. C. Moore, of Ilminster, has also kindly communicated some fragments which show sufficient elements of a similar structure, to satisfy Prof. Quekett and myself of the presence of these bodies, but as they occur in hard limestone, they cannot easily be detached, or very readily recognized. Still more recently, Mr. Gough, of Kendal, has sent me portions of the skin of an *Ichthyosaurus* in his collection, which display these forms very perfectly and distinctly.

DESCRIPTION OF PLATE V.

Fig. 1. Subvertebral bone of *Ichthyosaurus* (one of the wedge-bones of the cervical vertebræ), partially coated with the remains of the skin. Nat. size.

Fig. 2. A patch from the lower left-hand corner (*) of Fig. 1; seen by reflected light; magnified 25 diameters.

Figs. 3, 4, 5. Setiform scales; seen by reflected light; magnified 50 diameters.

Figs. 6–13. Setiform scales, seen by transmitted light; showing more or less of the component elements of their structure;—fig. 6, magnified 100 diameters; figs. 7–13, magnified 45 diameters.

† Bridgewater Treatise, vol. ii. p. 22; and Trans. Geol. Soc. Ser. 2, vol. vi. p. 199 *et seq.*

2. *On the* Geology *of* Quebec *and its* Environs.

By J. J. Bigsby, M.D., F.G.S., Mem. Amer. Phil. Soc. Philadelphia.

[Plate VI.]

Quebec, with its environs, presents an instructive field of investigation to the geological student in its abundance of natural sections of the earlier palæozoic strata, and particularly in its ample development of the "Hudson River Group" of the State of New York. We have here also very interesting deposits of the glacial period *; but of them I shall not speak in this paper—having little to add to the statements of Sir Charles Lyell, Prof. Emmons †, and Capt. Bayfield.

Topography.—The city and fortress of Quebec crown the lofty bluff at the N.E. end of an elevated tract, that, rising like an island (which once it was), a few hundred feet above the general surface, forms the north shore of the River St. Lawrence for $7\frac{1}{2}$ miles south-westwards (up-stream).

This tract is rather narrow, and is highest in the middle and about Quebec. Its gentle undulations are covered with woods and farms. While on the N.W. it dips by short ledges and grassy steeps into low meadows a mile or more broad, to ascend again by earthy shelves into the neighbouring mountains; its S.E. flank consists of rocky cliffs and slopes, varying from 50 to 370 feet in height, and overlooking the St. Lawrence. The Upper Town of Quebec stands on the bluff just mentioned, and the Lower Town, at its base, on made ground, being 240 yards in greatest breadth in Rue sous la Fort.

The military works enclosing the Upper Town are about $2\frac{3}{4}$ miles in circumference; their principal face being S.W. towards the Plains of Abraham.

Cape Diamond rises higher than any other part of the bluff or promontory by 50 or 60 feet, and overlooks a contracted part of the St. Lawrence from an elevation of 372 feet. It is absolutely perpendicular in most places, and bare. From the highest parts of this Cape, the ground on which the Upper Town stands shelves gently downwards towards the N.W., as far as a steep called "Coteau de Geneviève," where a nearly perpendicular descent takes place of more than 100 feet.

The picturesque headland nearly opposite to Cape Diamond on the south side of the River St. Lawrence is Point Levi. For 200 feet from the level of the beach it is a shattered cliff, and then rises as high as Cape Diamond in a grassy slope.

From Point Levi downwards, for fourteen miles, high cliffs prevail along the south bank of the river; but the opposite or north bank is in taluses and broken steeps.

The country south of the St. Lawrence maintains for many miles in all directions the elevation observed at Point Levi. It is a rough undulating plain of woods and farms, traversed at intervals by low ridges of almost naked rock.

* In the accompanying map the extent of the glacial deposits is approximately defined, from my own observations.

† Emmons, Geology of New York State, p. 128.

From Point Levi upwards, the south bank of the river is either a line of rocky cliffs, or steep earthy slopes overlooking strips of beach.

The north side of Quebec Basin, although marshy and low about the mouth of the River St. Charles and the Canardière, rises at the long village of Beauport, and is 300 feet high about the River Montmorenci, nine miles from Quebec. The land here ascends slowly towards the mountains on the north, which are from five to ten miles distant from the St. Lawrence.

In order to avoid further detail, I beg to refer the reader to the accompanying map for the other and minor features of this locality. See Pl. VI.

General geological notices.—Quebec, with its environs, is placed on the north flank of what we may, for the present, consider the great trough of the St. Lawrence, near a range of high round-topped mountains, principally gneissoid, which, coming from the S.W., strike the St. Lawrence twenty-eight miles below Quebec in the massy promontory of Cape Tourment, 2200 feet high.

This trough is bounded on the south, about 100 miles from the St. Lawrence, by a continuation of the Green Mountains of the United States,—not as an unbroken elevation, but as a closely packed series of hills, ridges, and bosses of granite, trap, mica-slate, &c., having a general trend to the N.E.

Most of the champaigne country of this trough is filled up, for some thousand square miles, with clay-slates, sandstones, conglomerates, and limestones, chiefly belonging to the "Hudson River Group" of the New York State geologists; interspersed with serpentine and dolomite. All are more or less conformable to the crystalline rocks of the region they occupy, and become metamorphic in the mountain belt itself. In the rough forest plain it is quite common for there unexpectedly to protrude a detached hill, a low knob, or a mere swollen indication, still covered up, of granite or trap, which deranges all the surrounding sedimentary strata. Indeed foldings, curvatures, and dislocations are here very numerous, and are as characteristic of this region as the *undisturbed* condition of these rocks is of the countries west of Lake Champlain.

Some of the calcareous rocks of this trough are for very long distances (700 miles N.E. and S.W.) distinctly Upper Silurian, according to Mr. W. E. Logan, to whose skilful investigations, amid hardships and difficulties of every kind, we owe all the geological information we possess of these almost trackless wilds.

After these preliminary observations we proceed to state, that Quebec with its environs is based on the following series of rocks, beginning from below:—Gneiss, Potsdam Sandstone, Trenton Limestone, Utica Slate, and the Hudson River Group of the State of New York.

On each of these rocks we shall make some general remarks; and then shall describe minutely a few localities which are to be taken as explanatory types of the district;—hoping thus to secure some degree both of clearness and brevity. It must be premised, however, that the unnoticed parts also have been carefully examined.

Gneiss.—The gneiss is of the kind prevailing in the Canadas. It is reddish-grey and greyish-red, coarsely granular, rarely porphyritic; the quartz very abundant, mica scanty. It splits into large leaves, and is traversed irregularly by seams of white quartz. Now and then we find a chloritic powder disseminated in it. It has a general trend N.E. and S.W. We have only to deal with it in two places; at Jeune or Indian Lorette, eight miles, and at the Falls of Montmorenci, nine miles from Quebec. It is here as outlying portions of the round-topped mountains on the immediate north already referred to.

Potsdam Sandstone.—The Potsdam sandstone* only occurs distinctly, as far as is yet known, in this neighbourhood at the Falls of Montmorenci, but at Jeune Lorette there are traces of it.

The sandstone of Montmorenci has been unhesitatingly declared to represent the Potsdam rock by the New York State geologists, as well as by Sir Charles Lyell and Mr. Logan. With these high authorities I have only to concur. Its geological position is that of the Potsdam sandstone; but its aspect and mineral condition are very different from that of Lake Superior and of the Thousand Islands near Kingston, Upper Canada. We know, however, that this rock changes its constituents singularly even in the same basin. It will be described when treating of the River Montmorenci.

Trenton Limestone.—The important strata, which have been named by American geologists Calciferous sandstone and Chazy limestone, do not hereabouts succeed Potsdam sandstone, as might have been expected. The former is found fifty miles to the N.E., at St. Paul's Bay (Logan). We find about Quebec Trenton limestone reposing horizontally either on the Potsdam rock, or directly on gneiss. Its position and fossil contents clearly proclaim its age; which none dispute. The description by Professor Emmons of the typical rock in the State of New York is literally that of the horizontal limestone of the north side of the St. Lawrence,—not only in the vicinity of Quebec (Beauport), but *for great distances* above and below that city; and it is curious to observe, thirty miles and more below Quebec, patches and shreds of this rock adhering to the naked river-face of Cape Tourment, which dips into the St. Lawrence in shattered cliffs of gneiss 700 and 800 feet high.

Dr. Gerard Troost found the Trenton limestone of Montmorenci to have nearly the same chemical composition as the aluminous limestone of Quebec (Hudson River Group); but with less alumina and carbon (*vide infra*, p. 91). The accidental minerals of this rock are various common forms of calc-spar, purple and colourless fluor spar, small rock-crystals, bitumen, both concrete and fluid, and massive blende,—all, except the last, being in druses.

The Trenton limestone is here confined to the north side of the St. Lawrence. All the eight streams which flow from the adjacent mountains into the St. Lawrence cut through more or less of this rock. The various quarries in the intervals show that it is there the uppermost rock. It is in bare ledges for a couple of miles together

* The equivalent probably, according to Sir Roderick Murchison, of the "Lingula beds," at the bottom of his Silurian series of Welsh rocks.

about Beauport, and is particularly well seen in the Rivers Montmorenci, St. Charles, and Petite Ruisseau.

Utica Slate.—Utica slate has been recognized here by the best observers in a uniform dark shale, with few fossil remains (*Triarthrus Beckii*); but it must be of small thickness (though not yet ascertained), because in this vicinity it soon loses its characteristic* of never containing fragments of other rocks. It is, in fact, a development of the shaly part of the Trenton limestone, interposed between the limestone and the next series of strata, the Hudson River group; and it, therefore, may here be considered as a thin band between the Trenton limestone and the Hudson River group, into which its passage is gradual.

Hudson River Group.—The Hudson River group (Caradoc sandstone of Wales) occupies large portions of the north shore of the St. Lawrence and all the region south of this river, for more than 100 miles in all directions.

The northern boundary in the environs of Quebec (see Map) may be thus stated. It crosses the river from the seigniory of Tilly on the south shore, 14 miles W.S.W.$\frac{1}{2}$W. of Quebec, a little to the west of St. Augustine's church, $4\frac{1}{2}$ miles above Cape Rouge, and then bends round to the N.N.E. by Old Lorette, traverses the River St. Charles, one mile (or less) below Indian Lorette, and continues E.N.E. to the Mill of Charlesbourg. From hence eastwards, it strikes the River des Anges a few hundred yards above the King's Mill, and afterwards (obscured by Drift) proceeds to the beach of Quebec Basin, west of, and near to the mouth of Beauport River. It is from thence continued as a narrow border southwestward along the Canardière; and northeastward, along the edge of the basin, to Montmorenci, Ange Gardien, and so on for many miles.

Both the Utica slates and the Hudson River group correspond in this neighbourhood in all essential particulars, in their fossil contents, mineral structure, and habits, with their prototypes of New York, and they have been received as such by Professors Emmons and Mather, and by Sir Charles Lyell.

From the continual alternation in single layers, or in sets, of all the strata composing the Hudson River group of this region,—from their occasional recurrence at distant intervals in the same or nearly the same forms,—from their mutually affecting each other's composition,—and from their general conformability, the same general epoch must be assigned for the deposition of the whole, however vast the space they cover.

The only stratum that seems to require description is the sandstone, which was form rly called "greywacke." Its aspect is more that of a grit than of a sandstone. It is an aggregate of oblong or rounded masses of hyaline quartz, varying from a microscopic size to that of a horse-bean, or even of a walnut; but a pin's head or a pea represents their most common size. This rock contains worn fragments of brown and black quartz; and, in separate localities, a little

* Vanuxem, Geol. Reports of State of New York, p. 56.

red felspar, more or less white mica, small masses of black clay, angular fragments of green clay-slate, copper and iron pyrites, and plumbago. In two places at least, fragments of a shell resembling an *Orthis* have been found in this grit.

Organic Remains.—Fossil remains are numerous in places; they are often comminuted. The following list includes all in my possession at present from the vicinity of Quebec. Formerly I had others, but they are lost. I am not aware of any published list, perfect or imperfect. I beg to express my cordial thanks to Mr. Salter, of the Museum of Practical Geology, for his great kindness in naming all these fossils, excepting the labrum of a Trilobite, for which I am obliged to Mr. Woodward, of the British Museum.

List of Fossils found near Quebec.

In Trenton Limestone.	
Calymene senaria	River Montmorenci.
Phacops, n. sp.?	River Montmorenci.
Asaphus (Isotelus) gigas	Montmorenci and Beauport.
Labrum of ditto	Beauport.
Trinucleus concentricus	Montmorenci and Beauport.
Illænus Trentonensis?, possibly new species, of the Bumastus group	Indian Lorette.
Orthoceras proteiforme	Montmorenci.
—— strigatum?	Montmorenci.
Oncoceras constrictum	Indian Lorette.
Lituites undatus	Indian Lorette.
—— (Trocholites) ammoneus	Montmorenci.
Bellerophon bilobatus	Montmorenci and Lorette.
Murchisonia bicincta	Montmorenci and Lorette.
Conularia Sowerbyi (C. quadrisulcata, *Sil. Syst.*)	Beauport, Montmorenci, and Lorette.
Strophomena alternata	Montmorenci.
Lingula quadrata	Montmorenci and Beauport.
——; a long species	Montmorenci and Indian Lorette.
Rhynchonella hemiplicata	Lorette and Beauport.
Encrinites; new, with excessively slender stem, arms, and tentacles	Beauport.
Favosites fibrosus	Lorette.
Various millepore and ramose corals	Beauport and Montmorenci.
Utica Slate.	
Triarthrus Beckii	Montmorenci Chasm.
Graptolites pristis	Montmorenci.
Hudson River Group.	
Graptolites* pristis	Lorette, Lauzon.
—— (Didymograpsus); n. sp.? like *D. Murchisoni*, but with the cell-teeth apparently on the outside of the branches	Lauzon.
—— (Didymograpsus) caduceus, n. sp. (See fig. 1)	Lauzon.
Fenestella retiformis; 2 species	Lauzon.
Glauconome; n. sp.?	Lauzon.

* Two other *Graptolites* have been recorded as occurring at Point Levi, near Quebec; see Quart. Journ. Geol. Soc. vol. viii. Part 2. p. 19. These belong most probably to the Hudson River Group of rocks.

The following description of the new species of Graptolite has been kindly supplied by Mr. Salter.

DIDYMOGRAPSUS CADUCEUS, Salter. Fig. 1.

D. stipite filiformi longo; ramis retrorsum flexis, ferè parallelis; rachide utroque latiore, dentibus prominulis, appendice nullo.

This form is closely related to *D. geminus*, Hisinger; but the two branches are bent so much back, as to be nearly parallel, and the stalk is very long and threadlike.

From the Lauzon precipice.

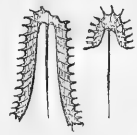


Fig. 1.—*New species of Graptolite,* Didymograpsus caduceus, *Salter, from the Lauzon precipice (Hudson River Group).*

Local geological Notices. River Montmorenci.—Since the Falls of Montmorenci and their vicinity afford good sections of all the rocks of the district, I shall commence my local descriptions there.

The River Montmorenci, after issuing from the adjacent forest-hills, traverses some broad gravelly meadows, in the midst of which a few ridges or reefs of gneiss give rise to a low cascade, called "The Three Leaps," about three miles from the St. Lawrence.

One mile and a half below this cascade the river cuts through a barrier of limestone half-a-mile across, at what are called the "Natural Steps,"—a very narrow gorge, whose sides are either mural or worn into the form of stairs or steps.

One-third of a mile below the Natural Steps is a bridge, and a few hundred yards lower down, the noisy river (its banks always high and rocky) plunges into a small round cove of the St. Lawrence, 228 feet below.

Gneiss is the lowest visible rock; and from below the Natural Steps it floors the river with reefs, peeping also from beneath the whole east bank down to the bridge, as well as in spots along the west bank. A few hundred yards E.N.E. of the bridge also, the gneiss emerges above the herbage in the fields, and, gradually attaining greater height and breadth, runs E.N.E. to join the mountains in the rear, and in a line nearly parallel to the St. Lawrence.

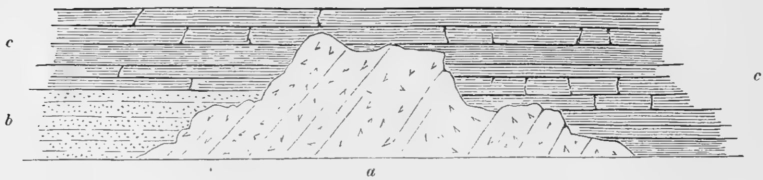
The Falls pass over a great cliff of gneiss which forms the centre of the cove which the falling waters have scooped out of the banks of the St. Lawrence; and its flanks are formed of sedimentary rocks, which are greatly, but not wholly, obscured by gullies, dislocations, talus, and vegetation. The strike of the gneiss is south-west, in broad flakes with frequent flexures; and the dip, when not vertical, is to the S.E. Potsdam sandstone rests upon gneiss horizontally, and therefore unconformably; itself supporting Trenton limestone.

The sandstone is plentiful on the east bank of the river, above the bridge, and is a yard and more thick, as well as on the west bank both above and below the bridge; the plane of contact with the enclosing rocks being clean and abrupt It is white, brownish-red, or

bright green, in well-defined layers. It contains very numerous nodules or fragments, chiefly of white translucent quartz, varying from the size of a pin's head to that of a horse-bean. These are cemented by a calcareous, opaque, friable matrix. On the west bank, below the bridge, this sandstone has, both imbedded in it and resting on the naked gneiss, large boulders of the same gneiss,—some weighing many hundred weight. One of these Sir Charles Lyell found by admeasurement to be 8 feet long.

When the water is low, an interesting fact is seen near the east bank, 350 yards above the bridge. On the prolonged flank of a mound of gneiss rest some horizontal layers of Potsdam sandstone. They gradually thin off as they ascend the mound and cease (see fig. 1), but the superincumbent limestone is continued, and, in immediate contact with the gneiss mound, covers its little crest and its opposite side.

Fig. 2.—*Section showing the superposition of beds of Potsdam sandstone and Trenton limestone on gneiss, River Montmorenci.*



a. Gneiss. *b.* Potsdam sandstone. *c.* Trenton limestone.

The Potsdam sandstone at this place has not yet been found to contain organic remains.

The Trenton limestone, which reposes conformably on the Potsdam sandstone, is amply displayed. It constitutes the whole mural gulley at the Natural Steps, and lines both banks of the river either in slopes or cliffs from thence to the brink of the great Falls. On the west side of the brink the cliff is 40 feet high, chiefly consisting of Trenton limestone with the rocks beneath well exposed.

The Trenton limestone at Montmorenci is fetid, moderately hard, finely granular, black, bluish, or blackish brown. Certain thin layers at every level are abruptly crystalline and pale brown; others again take on a quasi-conglomerate appearance, with rounded concretions, from the size of an orange downwards. At irregular intervals, a dark calcareous shale, from 6 to 18 inches thick, is intercalated; and this, as we shall find, is soon, under the name of Utica slate, wholly substituted for the Trenton rock.

The sides of the cliff over which the Montmorenci plunges into the River St. Lawrence show the manner in which the Trenton limestone passes into the next and upper division of Silurian rocks, Utica slate (represented in Wales by Llandeilo flags), and the Hudson River group; and it is thus:—on both sides of the chasm (the middle being wholly of gneiss) the Trenton limestone becomes rapidly both

argillaceous and quartzose, loses nearly all its fossils, and assumes a soft shaly structure, with a high dip to the S.E.,—the same which prevails for more than 100 miles in every direction but due north.

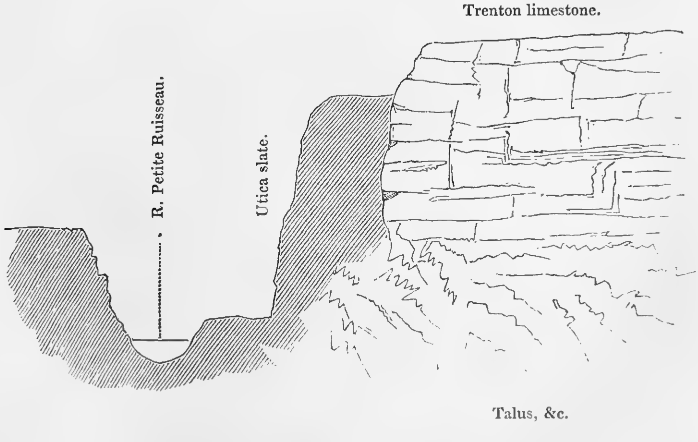
Looking up, from below, at the higher parts of this bowl-shaped chasm on the east side, we see, peeping from beneath rubbish and among shrubbery, displaced slabs of compact Trenton limestone, followed downwards by dark shales, while the lower parts of the precipice and the beach of the River St. Lawrence are wholly occupied by Utica slate in the full development of its crumbling rusty brown shales, its *Graptolites* and *Triarthrus Beckii*, the Trenton fossils having disappeared.

Beauport.—Continuing our observations both on the Trenton limestone and its connexion with Utica slate, it is to be noted that at Beauport, the village a little westward of Montmorenci, the change is well displayed.

Two hundred yards north of Col. de Salaberry's house in this village, we have in a quarry the genuine horizontal Trenton limestone. At only *fifty yards* north of the house, it is interstratified largely with black shale, and with a slight dip. In the streamlet *close* to the house, the rock is the true Utica slate dipping at a high angle to the S.E. (Capt. Skene, R.E.).

In the quarries about this village the Trenton limestone is full of shale, often coated with fluor-spar, copper pyrites, and calcedony. The bituminous druses are numerous, and often of the size of a walnut. Its fossils are scattered in patches; sometimes they are altogether absent, at others in inconceivable quantities. Some of the shaly layers are wholly composed of Trilobites (especially of the *Asaphus gigas*), or of *Rhynchonella hemiplicata*.

Fig. 3.—*Section at Petite Ruisseau R., showing the relation of the Utica slate to the Trenton limestone.*



R. Petite Ruisseau.—On the Petite Ruisseau, which falls into the

St. Charles five miles from Quebec, we find the Utica slate abutting directly on the Trenton rock in the manner represented in fig. 3.

R. St. Charles.—The cascade of the St. Charles at Jeune Lorette, eight miles W.N.W. of Quebec, is an interesting spot. Here the river leaps over a ledge of gneiss into a deep gorge, with mural sides for the most part and half a mile long.

Close to the foot of the cascade, the coarse granular gneiss, faced by water-worn bosses full of cracks, is covered on both banks by Trenton limestone, but not completely on the left behind the Mill.

Although Potsdam sandstone has not been detected as yet, doubtless it is near at hand, for angular blocks of the gneiss of the locality lie upon the fixed rock, with a dirty powder about them as at Montmorenci, but there is not the same pale, friable, calcareous cement.

Adapting itself and firmly adhering to the inequalities of the gneiss above spoken of, Trenton limestone (in no respect different from that of Montmorenci) enters and fills its deep fissures. A few inches above the gneiss the limestone becomes horizontally stratified, in thicknesses varying from 6 to 18 inches, both at this place and between the mill and the village church.

On the west bank, close to and below the Falls, the limestone dips gently to the south; and 100 yards further down the gorge, the strata are very massive, and dip to the east* at an angle of 30°; but they dip to the S.E. in an adjacent field on the west.

Not many yards below this we come upon the true argillo-calcareous shale of Utica slate, with *Graptolites* and few or no other fossils, whilst the Trenton beds close at hand are found full of characteristic organic remains.

Hudson River Group at Quebec, along the N. shore of the St. Lawrence, and South of the St. Lawrence.—We now proceed to notice the black shales, ferruginous clay-slates, sandstones, limestones, and various conglomerates which prevail so enormously on the south of the St. Lawrence, and whose innumerable intercalations show such singularly frequent changes of condition in the sea which deposited them. They are, as before said, the Hudson River Group of the State of New York.

Their northern boundary near Quebec has been already given. Mr. Logan† states that on the south side of the St. Lawrence, from the river Chaudière near Quebec to the Temiscouta Road, a distance of about 130 miles, the strata in an ascending series from Trenton limestone and Utica slate, consist of—

1. Dark grey clay-slates, sandstones, and limestones; in very thin beds; fossiliferous, with *Graptolites*. This division is only seen on one spot E.S.E. of Quebec, opposite the lower end of the Island of Orleans, but prevails largely S.W. of Quebec.
2. Grey, green, and red shales, with bands of thin calcareous conglomerate.
3. Hard sandstones, grey, greenish, with a little mica. Sometimes calcareous conglomerate, with Trenton fossils.

* Possibly a displacement from local causes.

† Report on the Geology of Canada, 1849–50, p. 32 and *passim*.

4. Red and green shales, titaniferous.
5. Coarse-grained green sandstones, with more mica, and some plumbago.

This is an accurate statement in the general. It is the business of this paper to give some of the minuter features of the district of Quebec, features which I believe have not been published in detail by Mr. Logan.

In the course of this paper nothing more will be said of Utica slate. The Hudson River Group will be described, first as it appears in the promontory on which stand the city and suburbs of Quebec; and secondly, on the Quebec ridge, along the north shore of the St. Lawrence. Then crossing the River St. Lawrence, the fine exposures about Lauzon Pier and Point Levi will be noticed; together with the adjacent interior as far as the village of St. Henry.

Quebec.—The great body of the Quebec promontory is limestone, massed together in a thickness unusually great for the Hudson River group. It is black, or brownish black, finely granular, dull and conchoidal in cross-fracture; hardness variable; sp. gr. 2·5–2·7. According to an analysis kindly made for me by Dr. Gerard Troost, late State Geologist of Tennessee, it consists of—

Carbonate of lime........	78·0
Alumina	15·5
Coal and bitumen........	6·5
Parts....	100·0

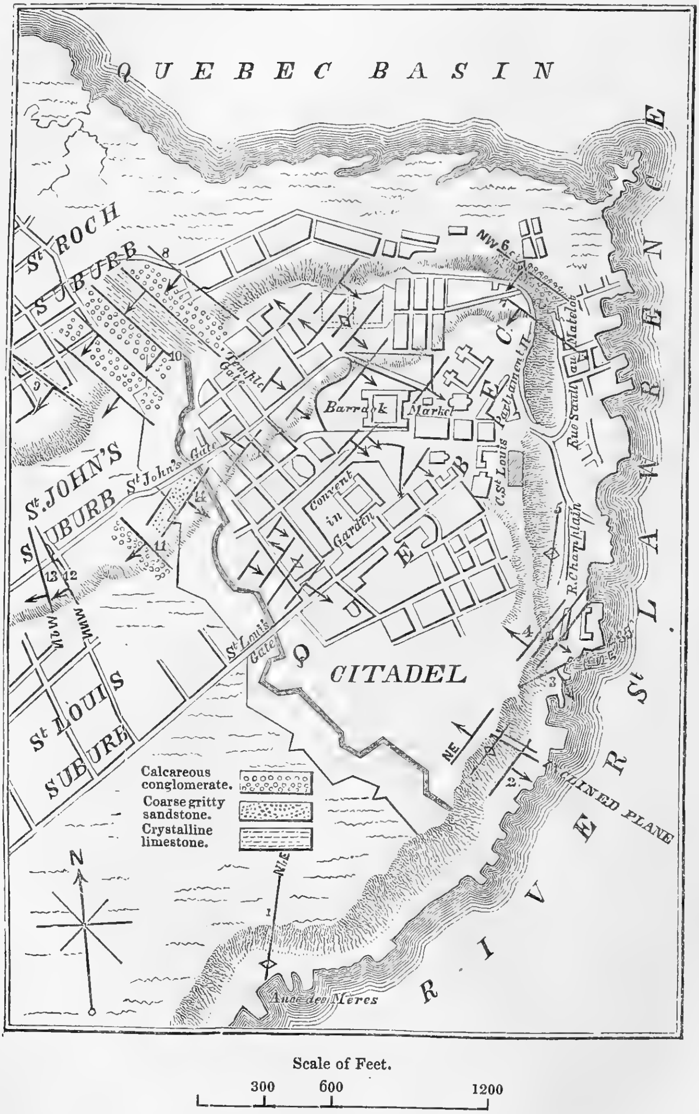
It is usually in layers a foot thick; but, as it splits and shivers readily when exposed to frost, it is often shaly, and is always a bad building stone.

On the surface of the natural cleavages there is usually a high black polish, or a brown and red metallic glaze, like that of certain English pottery,—an appearance very striking on the perpendicular sheets of rock, of several hundred square feet, which form the face of the precipice overlooking the west end of Champlain Street, Quebec.

The strike of the great body of this aluminous limestone (see fig. 4) is S.W. and N.E., with a very high dip to the S.E., conformably to the Hudson River Group generally, and to many of the crystalline ranges of the Canadas, not only hereabouts, but elsewhere. But there are not a few abrupt deviations in strike, reversed dips, and flexures, affecting considerable spaces together. The deviations are mostly on the N.W. skirt of the promontory, and are almost always at right angles with the ordinary strike. The small anticlinals and foldings are evidenced by vertical strikes being flanked by opposing dips. There are several visible in different parts of the city, but sometimes obscured by the encumbered state of the ground.

The most extensively exposed set of wavy flexures is in Sault au Matelot Street. Two of the layers here open and leave a lenticular interval, about 25 feet long, and filled with black limestone in one amorphous mass, veined with calc-spar. Most of the great deviations in strike or dip are comprised in the following list, and are marked in fig. 4.

Fig. 4.—*Plan of the City of Quebec, showing the variations of dip and strike in the black limestone forming the mass of the promontory, and in its associated bands of conglomerate, sandstone, and limestone.*



Ground Plan of Quebec with the Dips and Strikes.

	Strike.	Dip.
1. Ance des Meres, or Diamond Harbour, at Railed Stairs	N. by E.	vert.
2. Near Inclined Plane (at a high angle)	N.E.	{ N.W. S.E.
3. On Beach and adjacent Cliff, near La Porte's Tavern, ∠85°	E.N.E.	S.S.E.
4. Half-way between Inclined Plane and Champlain Street	N.E.	{ S.E. vert. N.W.
5. West end of Champlain Street	N. by E.	vert.
6. North end of Sault au Matelot Street	N.W.	vert.
7. Near this	N.W.	S.W.
8. Near Palace Gate..	N.W.	S.W.
9. Road descending into St. Roche suburbs, first from St. John's Gate	N.W.	S.W.
10. Outside City walls, near Palace Gate (a conglomerate)...	N.W.	S.W.
11. S.E. of, and near to, St. John's Gate (M. d'Estimauville's garden)	N.W.	
12. St. John's Quarries, W.S.W. of No. 11......................	N.N.W.	W.S.W.
13. Ditto............................ ....(∠50°–80°)	N. by W.	W. by S.
14. Coarse sandstone, in ditch at St. John's Gate	N.E.	S.E.

The rocks interleaved with the black limestone of Quebec are two kinds of true conglomerate, a coarse gritty sandstone or quartz rock (formerly called greywacke), and grey crystalline limestone. They bear a very small proportion to the general mass of the rock, and are principally observed on the north side of the city, and on the south flank of the Heights of Abraham.

In Rue Sault au Matelot, the entire face of the cliff overhanging the houses consists of a dark brown calcareous conglomerate, of rounded ash-coloured fragments of very various sizes, scattered sparingly through a black cement of the Quebec limestone. It passes into the body of the rock, but the cliff here running for a space with the strike, we see this puddingstone for some hundred yards.

Near Palace Gate, and so on westward in the cliff overhanging St. Roche's suburbs (see fig. 4), another form of calcareous puddingstone is several times interleaved with the black limestone, dipping S.W. In this the imbedded masses are much more numerous, are seldom an inch square, often angular, and have chlorite and iron-pyrites interspersed. It is well seen in M. d'Estimauville's garden. In St. John's suburbs, 400 yards N.E. from this garden, the Matelot Street puddingstone recurs, 12 feet thick; its nodules very small, few, and rounded. Its strike is to the N.W. The layers of light brown semi-crystalline limestone, from a quarter of an inch to 15 inches in breadth, referred to above, occur between the suburb of St. John and that of St. Roche, and are intercalated at intervals of some feet from each other. They are not fossiliferous. At present I am only aware of the occurrence of coarse-grained sandstone (the coarse green sandstone of Logan, and described above, p. 91) in the military ditch on the left of St. John's Gate, and on Cape Diamond. The former bed is visible for 50 yards, and dips to the S.E. at a high angle. It is in one part 12 feet thick, and slowly narrows to 6 feet. Of the mass at Cape Diamond little is seen. It can scarcely belong to the bed at St. John's Gate.

I never saw or heard of any fossil remains of animal or vegetable life in the rocks upon which the city of Quebec is placed; a fact well known as being characteristic of the lower strata of the Hudson River series. The accidental minerals are fine smoke-brown and vitreous rock-crystals, and various common forms of calc-spar and fluor-spar. A bituminous mineral like coal is common, but small in quantity, in fissures and druses; shining and jet-black in the former situation, brown and powdery in the latter. In the Museum of the Literary and Historical Society of Quebec there is a block of this substance of the rare size of a cubic foot.

North shore of the St. Lawrence.—I shall now proceed to describe briefly the argillaceous shales and quartzose rocks which form the rest of the Quebec ridge, ending southwesterly at Cap Rouge. See Map, Pl. VI.

Its rocks are best seen along the shore of the St. Lawrence; for its upper surface is almost altogether covered with vegetation and soil. But, whenever rocks do appear, as on the road to Cap Rouge by the Plains of Abraham, or by the upper St. Foi Road, they are mostly red clay-slate, sometimes greenish blue, much weathered, and dipping to the south-east, with moderate deviations; thus carrying these strata into the river to the north of Quebec. Flexures, both so gentle as to be only wavings, and so minute as to be mere crumplings, are seen on these roads.

A little beyond the Quebec Race-course, on the high road by Marchmont, we meet with a patch of the conglomerate soon to be noticed at Lauzon (No. 10 of the list in p. 97). In one of its nodules of grey limestone I observed a bivalve (*Orthis*?). It here also contains long strips of clay-slate, placed lengthwise with the strike.

As may best be seen on the Map, the rocks of the lofty north shore of the St. Lawrence, from Quebec to C. Rouge, consist of frequent alternations of gritty grey sandstone (with occasional Bivalves) and red, brown, and black clay-shales. Near Quebec are intercalated calcareous conglomerates and grey limestones. The strikes and dips are laid down on the Map.

In proceeding from Quebec to Cap Rouge, along the beach of the St. Lawrence,—always under very lofty banks more or less precipitous,—and starting from near Ance des Meres, we find the aluminous limestone from thence to a road in Wolfe's Cove (which leads to the Plains of Abraham above) gradually becoming paler, more shaly, and less calcareous; being at last true clay-slate. We see interleaved (and obscured by talus) grey limestone and calcareous conglomerate, very like those near St. Roche, and probably their prolongations.

The whole of Wolfe's Cove rests upon this clay-shale, which is interspersed with thin bands of sandstone, all dipping south-west at a high angle.

At Point Pizeau sandstone increases in quantity, but still the greenish shale prevails, and the whole dip is more southerly.

As we approach the middle of Sillery Cove, the cliffs by degrees consist very much of fine and coarse sandstone, in thick seams parted

by shale. From the middle of Sillery Cove to Dr. Mills' Quarries ($1\frac{1}{4}$ mile westwards) brown and red shale alternate with sandstone, the dip being S. or S.S.E., at an angle often of only 15°.

In these quarries the sandstone, as usual, has a greenish matrix, with quartz pebbles as large as duck-shot, small flakes of plumbago, and silvery mica, and also with many fragments of shells (*Orthis*?). These shells were first noticed many years ago by Dr. Lyons, Surgeon to the Forces.

Beyond Dr. Mills' Quarries up to a nameless point three-quarters of a mile beyond, and at the narrowest part of the St. Lawrence for many miles up or down, the sandstone is black, and in hard thick strata interleaved with clay-shale in nearly equal quantities, the dip being high and S.S.E.; and still more easterly, it occurs in bold and extensive flexures which the nature of the ground will not allow of being traced out.

The little capes or points of land are generally of sandstone, this rock being less liable to destruction than the shale.

These two rocks now continue along shore in numerous intercalations of various breadths up to Cap Rouge; the red shale slowly gaining possession of nearly the whole surface of the slope, its strike (N.E. and N.N.E.) being parallel to the shore-line (see Map). From about half a mile westward of the Point at the narrows to Cap Rouge we see, with surprise, in the cliffs about and above high-water-mark, many angular blocks of dark limestone, of the sandstone of the place, and rounded boulders of gneiss, imbedded in the surface of the clay-shale. They have been raised and driven into it by the ice of spring freshets,—and this with immense force, because these boulders are commonly very large. The visible part of one of these buried masses of gneiss is 5 feet across. The uncovered end of one mass of sandstone thus thrust into the cliff is 3 feet long by $2\frac{1}{2}$ feet broad; it has displaced all the shale edgewise for three or four feet around. These blocks are generally solitary, but not always.

From Cap Rouge, the north shore of the St. Lawrence westwards to near the church of St. Augustine ($4\frac{1}{2}$ miles) is so covered by alluvium that little fixed rock, except occasionally shale, is seen; and we are carried out of the district that forms the subject of these pages.

South of the St. Lawrence from Point Levi to St. Henry.—Crossing now to the south side of the St. Lawrence we everywhere find the country based on the same minute alternations of clay-slate, coarse sandstone, calcareous and other conglomerates, that we met with on the north side of the river. The stratification is much more steadily to the N.E., with a south-east dip,—so varying by slow deflection as to give a waved appearance to the whole; remarkable contortions, however, will be pointed out in the proper place.

We will first traverse the country for ten miles S.S.W. to the village of St. Henry, crossing the strike, and then notice some of the larger rock-exposures in the cliffs about Point Levi, and for some miles along the River St. Lawrence east and west of that point.

The interior between Point Levi and St. Henry on the River Etchenim for the first third of the distance rests upon green and red clay-slate with very thin layers of sandstone, as far as soil and herbage will allow of inspection; but about this point we cross small scrubby eminences of sandstone, in parts so coarse as to be a puddingstone of large white quartz-pebbles; but sometimes it is slaty and fine-grained, without a nodule visible, and of a pale green colour; at others its base is dark green, and full of black, white, and red quartz-pebbles, with an occasional bit of red felspar. The common dip is S.E., at an angle of 70°, but this is with many inflections, as before said.

These eminences of quartzose conglomerate are continuations of those which I saw near St. Thomas, thirty-five miles, as well as at Kamouraska, ninety miles east of Quebec, and which Logan traced as an anticlinal axis to the River du Loup, 130 or more miles from Quebec.

In the remainder of the distance from Point Levi to St. Henry clay-slate is in great force, but intercalated with greenish sandstone, in broader sheets; and, nearer to St. Henry, with pale crystalline limestones.

The River Etchenim, from St. Henry to its junction with the St. Lawrence, only exhibits the same facts. At this village, the shallow but broad river is traversed by bands of black and green clay-slates (hard and smooth enough to be used as hones), with a south-eastern dip, and alternating in thin beds with a highly conchoid translucent greenish-grey quartz-rock, dotted with grains of hyaline and opaque quartz. At the Falls, a little below St. Henry, the clay-slate is minutely interleaved with crystalline brown limestone and granular sandstone. These strata are much inflected and displaced; but their ordinary dip is S.S.E. at angles of 50° to 70°. At the mouth of the Etchemin the strike is E.b.S., dip N.b.E.

Lauzon cliff.—By returning to the south shore of the St. Lawrence opposite to Quebec, we shall see that the Hudson River group is much more complex than the encumbered state of the interior permits us to discover. The steeps and cliffs, and the beach about Lauzon and Point Levi, are principally composed of dark blue, brown, and green clay-slates, weathering into shales. They are of very fine texture, sharp-edged, and, when dark-coloured, abound in *Graptolites.*

But the slate is much seamed (and irregularly) with thin beds of pale crystalline unfossiliferous limestone (that of Quebec), with various sandstones, and seven kinds of conglomerates,—all in the space of a few hundred yards around the Lauzon Pier, as visible either on the beach or in the cliffs. These almost endless repetitions I have traced for fourteen miles eastward, to Beaumont; and less carefully for seventy-five miles further down the St. Lawrence; while westwards, up the river, they are to be noticed more or less, according to the nature of the ground, up to the limits of our district.

The strikes and dips are best learnt from the accompanying Map.

The seven conglomerates are all calcareous in their nodules and

matrix, but differ in the condition and kind of their imbedded materials.

No. 1 is the same as that of Matelot Street, Quebec.
No. 2 resembles that near the Palace Gate, Quebec.
No. 3 is No. 2, but full of minute irregular bodies of hyaline quartz.
No. 4. The materials of this conglomerate are both angular and rounded, and are veined with calc-spar; and it contains also some few round masses of quartz, white and brown, as large as nuts.
No. 5 nearly the same as No. 2, but with lumps of green clay.
No. 6 ditto, but with long slips of the red titaniferous clay-slate of the district.
No. 7 dark-coloured, full of fragments of the Trenton limestone of Lorette.

Two layers of the Matelot Street conglomerate occur east of, and near to, the pier at Lauzon, one being 15 feet thick. The other, nearly as large, undergoes a shift or fault close to the cliff.

The following local sections of these alternating strata (figs. 5 & 6) sufficiently represent the appearances frequently occurring here.

These interesting phænomena are met with on the first road leading up the hill to the west from the Ferry Wharf. The natural ledge which has here been taken advantage of for a road has been widened by paring away the rock on the left hand so as to display on a vertical surface many of the alternations under notice, as well as a remarkable set of contortions. These alternations occur in the upper third of the ascent, 200–250 feet in total height, and in the following order, descending from the top of the hill:—

1. The lower part of 37 feet of dark brown Graptolite shale.
2. A seam of calcareous conglomerate; pebbles large.
3. A few layers of shale.
4. Brown crystalline limestone, 6 inches thick.
5. Conglomerate No. 2 repeated. Towards the roof the pebbles are smaller.
6. Limestone, the same as No. 4.
7. Shale.
8. Limestone as No. 4, 8 inches thick.
9. Parti-coloured shale, 18 inches thick.
10. Calcareous conglomerate, 4 feet thick, with long slips (4–6 inches) of black and brown shale; pebbles very large.
    N.B. The same exists on Quebec Ridge, near Marchmont. (See Map, Pl. VI.)
11. Thirty feet of clay-slates or shales, grey crystalline limestones with dots of hyaline quartz, calcareous conglomerate with rather small pale pebbles, and another conglomerate with pebbles of black limestone, dots of hyaline quartz, and masses of green clay; all in conformable strata, varying in thickness from 6 inches to 4 feet, shales, of different colours, predominating in quantity.

Next below this set of strata come a nearly perpendicular set of

arches, 35 feet high, and 34 feet in diameter at the level of the road. Fig. 5 exhibits the beautiful series of arches alluded to. The symmetry of these arches, the delicacy of the laminæ, and the mode in which they end by impinging upon the adjacent stratum, are well worthy of remark.

Fig. 5.—*Section of arched strata on the side of the road at Lauzon Cliff.*

For 50 feet along the descent, below the arches, there is a repetition of the set of strata we have grouped above as No. 11, and then, to the bottom of the hill, little else but clay-slate with *Graptolites.*

Near the foot of this hill-road there is evidence of much disturbance in the breaking off from a layer of conglomerate of an angular mass 22 feet long by 6 broad, and its being thrust with violence partly into the midst of the adjacent clay-shale, and partly into the

conglomerate next above:—see fig. 6. The conglomerate from which this fragment has been detached has very small pebbles of limestone, lumps of black clay, fragments of hyaline and brown quartz, and grains of chlorite. Great disturbances are also met with in the fields above, and near this road.

Fig. 6.—*Section on the road-side, Lauzon Cliff.*

a. Calcareous conglomerate, pebbles very small; with lumps of black and green clay, and fragments of pale brown and hyaline quartz.
b. Clay-slate, enclosing a fragment of *a*, 22 feet long by 6 feet.
c. Coarse calcareous conglomerate, with fragments of pale limestone, often angular, and $3\frac{1}{2}$ inches long; hyaline quartz in drops, and long slips of clay-slate; white and red calc-spar in veins; rock-crystal and bitumen in geodes:—10 feet thick.
d. Clay-slate.

The upper conglomerate (10 feet thick) contains angular fragments of the diameter of $\frac{1}{2}$—$3\frac{1}{2}$ inches. They are pale limestone, green and black clays, and hyaline quartz. It has also druses of rock-crystals, white and red calc-spar, and bitumen in crusts and geodes.

Some yards west of this, a second road mounts the same broken cliff. It displays alternations of strata similar to those just described, but I refer to it on account of a coarse calcareous pudding-

stone near the bottom, with nodules of both pale and dark limestones. The dark fragments are identical with the limestone of Jeune Lorette, not only mineralogically, but as containing the same Trilobites, Corals, Encrinital stems, and *Murchisoniæ*. Mr. Logan states similar facts, but does not point out the localities.

The fissures of the clay-shale of this second road are often coated with copper-pyrites; and we meet with *Graptolites, Fenestella*, and *Glauconome*.

In the middle and at the foot of this road the strike is N.N.E. and the dip E.S.E. ∠85°.

Calc-spar veins are common in the conglomerates here, and intersect the nodules and matrix indifferently.

The strata along shore from here either westward to the mouth of the River Chaudière, or eastwards toward Beaumont, as far as they can be readily made out, are in kind and in mutual relation the same as those on the north shore of the St. Lawrence and about Point Levi; but the ground is unfavourable for minute examinations.

Ridges of clay-slate, principally red, but often green and black, with layers of greywacke, form the barrier of the Chaudière Falls.

A third of a mile east of the Lauzon Ferry there is a horizontal section of a set of contortions, the external layers of which gradually return to the normal direction in the manner represented in Pl. 38. fig. 5 of Sir H. De la Beche's "Geological Sections."

General observations.—The gneiss of the north shore of the St. Lawrence in this vicinity is of the kind prevalent in the Canadas, and is conformable to it. The group of round-topped hills and mountains, about twenty miles across, of which gneiss forms the greater part, trends N.E. and S.W., with valleys interposed of various sedimentary rocks, among which we find Trenton limestone.

[We find Potsdam sandstone to be extremely thin here, as has been verbally remarked by Sir R. Murchison. Its thickness increases as we travel westward, until in Lake Superior and in the Mississippi valley it is in great mass.—April 20.]

The Potsdam sandstone and Trenton limestone here rest unconformably upon the subjacent crystalline rocks, and are, therefore, posterior to them. The same takes place on the Great Lakes, at Montreal, Cape Tourment, Lower Canada, &c.

The fossil remains in the Trenton limestone occur only in patches, and the different localities, as Lorette, Beauport, &c., each have some exclusively. The *Asaphus gigas* and *Rhynchonella* herd together in particular beds.

Utica slate occurs in very limited quantity about Quebec; a narrow band only is visible, characterized by its uniform shaly aspect, and by the presence of *Triarthrus Beckii* and *Graptolites*. In fact, here as elsewhere, it speedily merges into the Hudson River Group.

The Hudson River Group is enormously developed in this part of North America. The tract occupied by it is at least 500 miles long, from Lake Temiscouta on the N.E., to the State of New York near Lake Ontario on the S.W.; and it extends from thence in great de-

tached fields to the State of Tennessee. Its breadth is always very considerable.

The black aluminous azoic limestone of Quebec is of unusual thickness for the Hudson River Group. This may be safely stated at 2000 feet, and might have been calculated at 5000 feet, but for the disturbances, which make an accurate estimate impossible *. The intercalations, it will be remembered, are few.

Natural concealments from wide waters, woods, and detritus prevent our tracing the extension of this limestone into the adjacent country.

Usually the Hudson River Group consists of rapidly alternating beds of clay-shale, sandstones, conglomerates, and limestone, from a few inches to 50 feet thick, and occupying wide tracts of country. It is curious to observe that the successively superadded beds have always the same general constitution and chiefly differ in the different state of the pebbles and fragments in the conglomerates and sandstones, and in the introduction of one or two new ingredients. These appearances seem to indicate a very prolonged epoch, during which a certain set of not very dissimilar acts have been repeated times all but innumerable, and upon the tranquil floor of a shallow sea, which was afterwards elevated.

The pebbles of the quartzose conglomerates are of the same peculiar white, bluish-white, or brown quartz that we see in the Potsdam sandstone near Kingston, Lake Ontario, at Gananoque, and Montmorenci.

One of the calcareous conglomerates is evidently derived from the Trenton limestone.

In so early deposits as the Hudson River Group, it is hard to point out the source of the drab-coloured pebbles of various shades so frequent at Lauzon and elsewhere. According to our present knowledge, we have only to look to the Birds' Eye and Calciferous limestones as their parent rocks; with these, however, I am but little acquainted. Nor do I understand clearly how the Hudson River Group came to be conformable to the gneiss of this district, with two unconformable strata of great thickness, and widely different, interposed.

* This limestone, it will be remembered, occupies the whole breadth of land from the River St. Lawrence across to the River St. Charles, in front of the Fortifications looking westerly, a distance of 1837 yards.

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——— Journal of Science and Arts. Vol. xiv. no. 42. *From Prof. Silliman, M.D. &c.*

Athenæum Journal, for November, December.

Belgium. L'Académie Royale des Sciences, &c. de la Belgique. Mémoires, tome xxvi.

———. Mémoires couronnés, tome xxiv. Collection en 8vo, tome v. part 1.

———. Bulletins, tome xvii. part 2; tome xviii. parts 1 & 2; and tome xix. parts 1 & 2.

———. Annuaire, 1851 and 1852.

Berlin Geological Society, Journal. Vol. iv. part 2.

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France, Geological Society of. Bulletins. Deux. Série, tome ix. feuill. 20–27.

Glasgow Philosophical Society, Proceedings. Vol iii. no. 4.

Jena, Annalen der Societat für die gesammte Mineralogie zu. *From G. B. Greenough, Esq., F.G.S.*

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Manchester Literary and Philosophical Society, Memoirs. 2nd Series, vol. x.

Modena. Memorie di Matematica e di Fisica della Societa Italiana delle Scienze residente in Modena. Tomo xxv. parte 1.

Montpellier, Académie des Sciences et Lettres de. Extraits des Procès-verbaux des Séances, 1850, 1851.

Nassau. Jahrbücher des Vereins für Naturkunde im Herzogthum Nassau. Heft 2, 3, 4, 5, & 8, 1 & 2 Abtheil.

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Quarterly Journal of Microscopical Science, No. 1.

Revista Minera, periodico cientifico é industrial. *From Prof. F. N. y Garza.*

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Royal Institution, Notices of the Meetings of the Members of. List of Members, &c.

Royal Society, Proceedings. Vol. vi. no. 90.

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Turin. Memorie della Reale Accademia delle Scienze di Torino. Serie seconda, tomo xii.

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————. On some Trails and Holes found in rocks of the Carboniferous Strata, and on Microconchus carbonarius.

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Bland, Thos. Contributions to Conchology, No. 10. *From Sir C. Lyell, F.G.S.*

Bland, Thos. Contributions to Conchology, No. 11.

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Microscopical Examinations, &c. of the Thames and other Waters. 1852. *From the London Spring-water Company.*

Orbigny, Alcide d'. Cours Élémentaire de Paléontologie et de Géologie stratigraphiques. Tome ii. fasc. 2.

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Quetelet, A. Sur le Climat de la Belgique. Parts 4 & 5.

Reports from the Rev. W. B. Clarke, relative to the Geological Surveys of New South Wales.

Report of the Provisional Directors of the London (Watford) Spring-water Company. 1852. *From that Company.*

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Wilkomm, Dr. Moritz. Die Strand- und Steppen-gebiete der Iberischen Halbinsel und deren Vegetation.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

MARCH 9, 1853.

The following communications were read:—

1. *On the* ALBERT MINE, HILSBOROUGH, NEW BRUNSWICK. By J. W. DAWSON, Esq.

[Communicated by Sir C. Lyell, V.P.G.S.]

PART I.

THE beds at this place were first noticed by Dr. Gesner*, who mentions the occurrence of bituminous shale, sandstone, and coal. They were subsequently visited by Professors Johnston and Robb, who state† that a thick bed of bitumen had been discovered, and a mining lease applied for.

* Third Report on New Brunswick.

† Agricultural Report on New Brunswick, 1849.

More recently the mineral deposit became a subject of litigation, and as the disputed right depended, or was supposed to depend, in part on its nature and geological age, scientific investigations were made at the instance of the parties interested. The scientific testimony was of a remarkably conflicting character. Dr. Jackson, of Boston*, Dr. Percival, Dr. Hayes, and other eminent geologists and chemists maintained that the substance is a "true coal," and that it occurs in the "true coal-formation." The late Mr. R. C. Taylor, F.G.S.†, the well-known author of the 'Statistics of Coal,' Dr. Robb, of Frederickton, and others, on the contrary, held that the substance is "asphalt or a variety of asphalt," and that it is a true vein occupying a line of dislocation. Having taken no part in the litigation of the question, and having recently enjoyed an opportunity of examining this somewhat anomalous deposit, I propose in the following paper to state the results at which I have arrived in reference to its nature and geological age.

1. *Geological position.*—According to Dr. Jackson, this is in the Coal-formation. Mr. Taylor inclines to the view that it is in the Old Red Sandstone; and Dr. Percival, while regarding the deposit as belonging to the Carboniferous system, admits that it underlies the red sandstone, gypsum, &c. of the vicinity, which are Lower Carboniferous. These differences of opinion are, I think, satisfactorily accounted for by what I believe to be the true place of the deposit, namely in *the lower part of the Lower Carboniferous series*, and on the geological horizon of a singular band of pseudo-coal-measures, which occurs in several places in Nova Scotia, below the great Lower Carboniferous marine limestones, and marks the dawn of those peculiar estuary and swamp conditions which prevailed so extensively in the middle and later portions of the Coal period.

In Nova Scotia, this member of the Carboniferous system usually consists of dark-coloured argillaceous, bituminous, and calcareous shales, with sandstones, and occasionally thin layers of coal. These beds contain a few coal-plants, especially *Lepidodendron*, and in some places abundance of scales of fishes (*Holoptychius, Palæoniscus*, &c.). They are well seen at Lower Horton, Horton Bluff, Windsor, Noel, Walton, Five Mile River, and Plaister Cove; and, as appearing at these places, have been described by the author‡ and Sir C. Lyell. It is somewhat singular that a comparison with this well-known group of rocks has not, so far as I am aware, occurred to any of the gentlemen who have written on the Albert deposit. The following are the grounds on which I would refer it to this particular place.

At the South Joggins in Nova Scotia, distant in a direct line about twenty miles S.E. from the Albert Mine, occurs a well-known section of rocks of the true coal-formation, dipping to the S.S.W. Following these beds in descending order, we find the lower carboniferous series, consisting of red clays and sandstones with limestone and gypsum,

* Report on the Albert Coal Mine, New York, 1851.

† Deposition of R. C. Taylor, &c., Philadelphia, 1851.

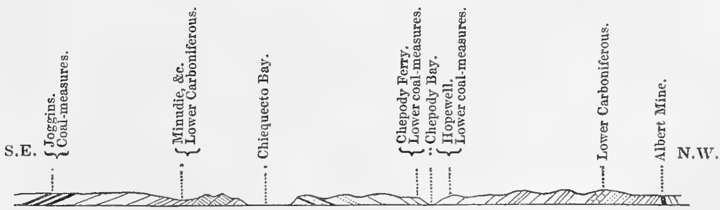
‡ Quart. Journ. Geol. Soc. vol. vi. p. 347, and note.

at Minudie, Napan River, and other places, and extending eastwardly to Pugwash, and, as I am informed, westwardly to Cape Merangouin. Proceeding to the N.W., however, we do not continue to find a descending series; but, on the contrary, passing over an anticlinal line, we find at Fort Cumberland and other places in New Brunswick, a repetition of the carboniferous rocks with northerly dips. The highest beds seen on this line of section appear at the Ferry, east side of Petitcodiac River; these are grey sandstones with *Calamites, Artesia,* and trunks of Coniferous trees, probably belonging to the lower part of the coal-measures. At Dorchester, and near Bennett's shipyard, on the west side of the Petitcodiac, the same beds are repeated with southerly dips (S.S.E. to S.E.), and thence to the Albert Mine, distant about ten miles. We have, as far as the nature of the ground will allow us to ascertain, a descending series, apparently as follows:

Grey sandstone, often coarse and pebbly, with shales and conglomerate;
Reddish sandstone;
Limestone and gypsum;
Red sandstone and conglomerate;
Grey and dark conglomerate;
Calcareo-bituminous shales of Albert Mine.

In the vicinity of the beds last mentioned are the metamorphic schistose rocks of Shepody Mountain, which I had an opportunity of examining in 1849; these are probably older than the Carboniferous system, and underlie the Albert shales, which seem to occupy the centre of an anticlinal running out from the metamorphic rocks into a carboniferous country. The order of superposition sketched above I have endeavoured to represent in fig. 1, which differs from a section

Fig. 1.—*General arrangement of the strata between South Joggins and Albert Mine.*



which I have seen in an anonymous pamphlet on the Albert controversy, principally in showing the anticlinal intervening between the Petitcodiac River and the South Joggins.

In the position above indicated as that of the Albert shales, and especially in the vicinity of the older formations, we should expect to find in Nova Scotia a group of rocks corresponding to them in lithological character, (except that the Albert shales are more highly bituminous than any yet known in that country). On the other hand, no group of shales in the higher members of the Carboniferous system

which include the ordinary productive coal-measures resembles these shales in lithological characters.

The most abundant fossils in the Albert shales are the remains of Fishes, some of which occur entire and in a beautiful state of preservation. Most of these fishes belong to the genus *Palæoniscus*, and several of the most perfect specimens are described and figured, and referred to new species, by Dr. Jackson*; and Prof. Agassiz informs me that the whole of a collection submitted to him belong to known carboniferous genera. Fossil plants appear to be rare, as is generally the case in beds of the period to which I refer these shales. I obtained at the mine only a few slender striated stems, which, as far as appearance goes, may have belonged to any geological period; but Dr. Jackson has figured a *Lepidodendron*, similar to, if not identical with, a species found at Horton Bluff, a *Flabellaria*, and *Calamites*. Collectively these fossils sufficiently establish the carboniferous age of the deposit, and they have also a greater resemblance to the grouping of organic remains in the Horton beds, than in any other part of that system.

It thus appears that the evidences of superposition, mineral character, and fossils concur in placing the Albert shales in the lower part of the Carboniferous system; and I may add, that a comparison of my observations with all the additional details given in the published reports still further confirms me in this view, which, as I have above mentioned, is also that of Dr. Percival, who seems to have examined the stratigraphical relations of the deposit with great accuracy, although he was probably not aware of the analogies of the deposit with beds of a similar age in Nova Scotia.

2. *Description of the Mine and its containing beds.*—Under this head, while treating only of facts ascertained by myself on the spot, I shall omit such as are not necessary to the explanation of the peculiarities of the deposit, referring for fuller details to the reports of Taylor, Jackson, and Percival.

The pit for the extraction of the mineral is situated on the south side of Frederick's Brook—a small stream, running eastwardly into the Petitcodiac,—and near the junction of two branches of the brook. In approaching the mine from the south, the bituminous shales are seen, in nearly a horizontal position, in a shallow road-cutting. This may be a deceptive appearance. Dr. Percival, however, considers it to be the true arrangement at this point. At the pit-mouth the beds dip to the south, at angles of 50° and 60°, and consist of grey and dark-coloured thin-bedded bituminous shales; and these shales appear with similar dips on the south branch of the brook. The outcrop of the coal† is not now seen, but in a line with it I observed a remarkable crumpling and arching of the beds in the bank of the brook, at the point where the southwardly dipping beds above noticed meet a similar or the same series dipping to the north-west; this is

* See 'Report,' above noticed.

† I call the substance *coal* for convenience, without in the meantime pledging myself to any view of its origin.

represented in fig. 2. The outcrop of the coal in the bed of the brook was, as I was informed, very narrow, and the appearances now presented are as if the shales had arched over it. On the northern side of the arch above referred to, and in the north branch of the brook, are seen a thick series of bituminous and calcareous shales, with three beds of sandstone, the whole dipping to the north-west at a high angle. The strike of one of the most regular beds I found to

Fig. 2. *Arched Strata, near Albert Mine.*

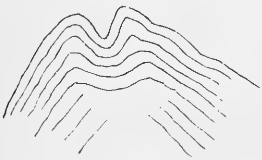
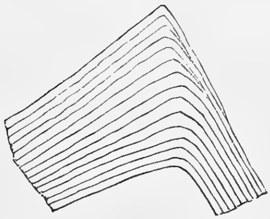


Fig. 3. *Bent Strata, near Albert Mine.*

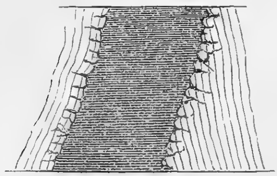


be S. 18° W. magnetic. Many of the shales contain scales of Fish, and one of them has a peculiar oolitic structure, consisting of a laminated basis of impure coaly matter or earthy bitumen, with crystalline calcareous grains, which are removed by weathering, and leave a light vesicular inflammable residuum of very singular aspect. The shales are in some places remarkably bent and contorted, as if by lateral pressure when in a soft state. A part of one of these flexures is accurately represented in fig. 3, and illustrates some appearances in the mine to be subsequently noticed.

The principal shaft has been sunk perpendicularly from the outcrop of the coal, and at its bottom is 67 feet south of it. The gallery connecting the bottom of the shaft with the coal shows thin-bedded bituminous shales with calcareous and ironstone bands and concretions, dipping at the end nearest the coal S.S.W., at an angle of 60°, though a dip to the S.E. is more prevalent along this side of the mine. The coal at this place is about 10 feet in thickness, and its upper surface dips N.W. about 75°. On the S.E., or under side, it rests against the edges of the somewhat contorted beds, already noticed as dipping to the southward, and on the north-west side it is overlaid by similar beds dipping in the same direction with the coal, but so much contorted as to present on the small scale a most complicated and confused appearance. The coal itself, as seen in mass underground, presents a beautiful and singular appearance. It has a splendent resinous lustre and perfect conchoidal fracture ; it is perfectly free from mineral charcoal and lines of impure coal or earthy matter. It is, however, divided into prismatic pieces by a great number of smooth divisional planes, proceeding from wall to wall, much in the manner of the cross structure seen in carbonized trees, and in the streaks of pitch-coal in the ordinary coals. At the N.W. side, or roof, the coal joins the rock without change. On the S.E. side, on the contrary, there is a portion of coal a few inches thick,

including angular fragments of the shale, some beds of which on this side are very tender and cleave readily into rhomboidal pieces. The coal enveloping these fragments must have been softened sufficiently to allow them to penetrate it, but it has more numerous and less regular divisional planes than in the central parts of the mass, and has probably been shifted or crushed somewhat, either when it received the included fragments or subsequently. Both at the roof and floor, the coal shows distinct evidence of a former pasty or fluid condition, in having injected a pure coaly substance into the most minute fissures of the containing rocks. On both roof and floor also, but especially the latter, there are abundant evidences of shifting and disturbance in the slickenside surfaces with which they abound. All these appearances I have endeavoured to represent in fig. 4, which agrees in the essential points with a similar figure given by Prof. Taylor, who does not, however, represent the contorted state of the beds and the crushing of the lower side of the coal.

Fig. 4. *Relation of the "Albert Coal" to the containing beds, as seen near the shaft of the mine.*



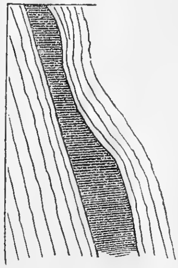
The levels of the mine extend on both sides of the shaft along the course of the coal. On the south-west they extend about 170 feet, when the coal narrows to a thickness of one foot. In this direction, however, I had not time to examine them. In proceeding to the N.E., the coal has a general course of N. 50° E., bending gradually to N. 65° E., and everywhere presenting the appearances already noticed, though attaining, in one place, a width of 13 feet. At the distance of about 200 feet from the shaft, a remarkable disturbance occurs. The main body of the coal bends suddenly to the northward, its course becoming N. 29° E.* for about 25 feet, when it returns to a course of N. 50° E. At the bend to the northward, a small part of the vein proceeds in its original course, and is stated by the persons connected with the mine to run out, leaving a large irregular promontory of rock between it and the main body of the coal. This disturbance has been variously represented as a fault, and as a cutting of the vein across the strata. Though I confess that the appearances are of a puzzling character, and are but imperfectly exposed in the mine, the impression left on my mind is that it is, on a large scale, a flexure similar to that represented in fig. 3, and accompanied by a partial tearing asunder of the beds. It seems evident that the beds must have been in a soft state at the time when this disturbance occurred, although there may have been subsequently some vertical shifting, especially on the west side of this "Jog."

Beyond this flexure, the deposit contracts in width, and becomes more regular, and eventually its containing walls assume a conform-

* These measurements were made with a pocket prismatic compass. They differ slightly from those of Dr. Jackson, either from accidental circumstances, or from being taken in different levels of the mine.

able dip to the S. 5° E., at an angle of 69°. The appearance presented at the time of my visit in the extreme end of the most advanced level, is represented in fig. 5, where it will be observed that the S.E. wall still shows indications of the prevailing contortions of the beds, and of the manner in which these cause the ends of strata to abut against the coal.

Fig. 5. *Section of the beds at the East end of Albert Mine.*



At this place, an exploratory level, driven to the S.E., shows a series of bituminous shales, with bands of ironstone, dipping regularly to the south-eastward. I could not, in any part of the mine, find beds corresponding to the Stigmaria-underclay of ordinary coal-seams, though on the S.E. side some of the beds are of a more compact and purely argillaceous character than those on the N.W. side, or roof, of the seam. The ironstone bands and fish-bearing shales are, however, not very dissimilar from those in some coal-measures of the ordinary coal-formation. They present no indications of metamorphism or of the passage of heated vapours, and all their appearances show that their bituminous matter has resulted from the presence of organic substances at the time of their deposition.

It is evident that all the above phænomena can be explained on the supposition that this coaly mass occupies a fissure running along an anticlinal bend of the strata; and that, apart from the character of the mineral and the containing beds, this would be the most natural explanation. On the other hand, when we consider the contorted condition of the beds, indicating disturbance when in a soft state, and the slickenside joints, pointing to subsequent shifts, we cannot refuse to admit that a conformable bed of true coal, if subjected before and after its consolidation to such movements, might present all the appearances of complication and disturbance observed in this mass, more especially if originally of small extent, and thinning out toward the edges. On this view we should have to suppose,—1. Disturbance and contortion of the beds while soft, and, at the point in question, a regular and somewhat abrupt arching of the beds; 2. A fault throwing down the south side of the arch along a line, coinciding in part of its course with the highly inclined underside of the coal at the north side of the arch; and 3. Removal of the upper part of the north side of the arch by denudation. Fig. 6 represents the appearances which would thus be produced, and it will be seen that they very closely correspond with the present condition of the deposit, not excepting its thinning toward the surface. If this be the true explanation, it is probable that the sunken south side of the bed has not yet been reached in the excavations. It might, however, in approaching it from above, show a succession of wedge-shaped included masses of rock or "horses," one of which I saw in the floor of the lowest level. On this view, also, the "Jog" or fault, above-described, may be a lateral bend received by the bed in the original contortion of the strata; and at this point the straight fracture, pro-

ducing the supposed downthrow, may have left the bed, and thus caused the appearance of the vein running in the former course of the bed along the line of fault, and also the greater regularity of the bed beyond the "Jog." This explanation is represented in fig. 7.

Fig. 6. *Ideal representation of the cause of the appearances at Albert Mine.*

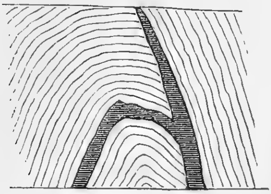
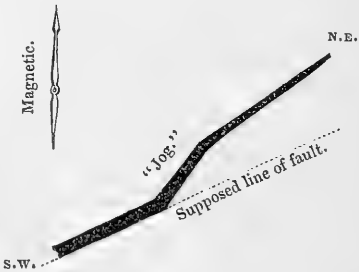


Fig. 7. *The "Jog" at Albert Mine, and its supposed relation to the line of fault.*



Part II. [*Abstract.*]

The author then proceeds to describe the character of the mineral in detail. He considers it, not without doubt, as Pitch-coal. He gives comparative examinations of it and of Jet from Whitby, and shows a similarity of constitution which he considers to indicate similarity of origin. Mr. Dawson has not been able to detect organic structure in it under the microscope*, though such are stated to occur by Mr. Bacon of Boston.

Respecting its origin and mode of formation, he remarks that two alternatives present themselves:—1. The substance may have resulted from a hardening of bitumen, the mode of formation being similar to that of asphaltum: 2. It may, like jet and other coals, have resulted from the bituminization of woody matter under the long-continued action of moisture and pressure.

He discusses the probabilities of each hypothesis, and remarks that each is accompanied by serious difficulties. After a careful consideration of the circumstances of the case, he adheres to the second view, not, however, without hesitation.

* Professor Quekett, of the Royal College of Surgeons, has kindly supplied the following Note:—

I have examined many specimens of the jet-like substance from the Albert Mine, Hilsborough, and can find no trace whatever of vegetable structure in them. Fractured pieces of this substance present some peculiar characters, having an exceedingly thin edge from which numerous sharp spicula project, such as are seen sometimes in fractured glass. These spicula are of various sizes and lengths, and are evidently composed of the same material as the mass from which they are given off. There is a great tendency even in the prepared slices to split up into these spiculate bodies, the ends of which are frequently divisible into still finer filaments.

Note on the Fossil Fish *from* Albert Mine. By Sir P. de M. G. Egerton, Bart., F.G.S. &c.

The specimens of the fossil fishes from the Albert Mine that are in Sir C. Lyell's Collection and the Museum of the Geological Society all belong to the genus *Palæoniscus*. Specimen marked No. 1 probably belongs to the species named *P. Alberti* by Dr. C. J. Jackson*. No. 2 is most like *P. Cairnsii*. No. 3 corresponds with the species figured pl. 2. fig. 3. This is not named in Dr. Jackson's description, but probably is also *P. Cairnsii*. The head-bone and scale, specimen No. 4, appear from their size and character to resemble the characters of the species figured pl. 1. fig. 5, but not described.

All the species from this locality are remarkable for the remote position of the dorsal fin, and the highly sculptured ornamentation of the head-bones and scales. They are also remarkable for the large size of the scales covering the dorsal angle. Some of the larger specimens figured by Dr. Jackson, especially fig. 2. pl. 1, have great resemblance to the forms of *Palæoniscus*, graduating into the characters of *Eurynotus* and *Amplypterus*, found at Burdie House and Newhaven in Scotland. They are all quite remote in character from the *Palæonisci* of the Kupfer Schiefer and Magnesian Limestone.

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2. *On the* Carcharodon *and other* Fish Remains *in the* Red Crag. By S. V. Wood, Esq., F.G.S.

March 23, 1853.

William Fairbairn, Esq., Theodore Stanley Heneken, Esq., Thomas H. Henry, Esq., H. H. Howell, Esq., Lovell Reeve, Esq., John Kenyon Blackwell, Esq., and Herbert Francis Mackworth, Esq., were elected Fellows.

The following communications were read:—

1. *On some* Tertiary Deposits *in* San Domingo. By T. S. Heneken, Esq., F.G.S. *With Notes on the* Fossil Shells, by J. C. Moore, Esq., F.G.S.; *and on the* Fossil Corals, by W. Lonsdale, Esq., F.G.S.

The following remarks on the geology of a part of the island of San Domingo† (made at intervals during the hurry and excitement of war and revolution) are offered not so much with a view of possibly disclosing any new or interesting facts, as from a desire to contribute, though it might be imperfectly, to the extension of geological statistics, as regards an interesting region hitherto but little known.

* Report on the Albert Coal Mine, 8vo, p. 22, &c.

† See also some remarks on the geology of this portion of San Domingo, by the Author, Quart. Journ. Geol. Soc. vol. vi. p. 39 *et seq.*

The island of San Domingo is one of the large Antilles; it forms a connecting link with the islands of Cuba and Porto Rico, the three acting as a vast dyke that confines the waters of the Carribbean Sea and Gulf of Mexico as they are forced in by the great Equatorial current, and which afterwards escape through the narrow passage between Cuba and the coast of Florida.

In an economic point of view, the geology of S. Domingo is of interest on account of its mineral riches, and especially its stores of fossil fuel, indicated by numerous outcrops of coal (lignite), which may at a future time be available for the important commercial interests of our country.

Metamorphic and crystalline rocks are the chief component materials of the central chain of mountains called the Cibao*, from which distinct ridges branch off in some places towards the coast. These mountains rarely exceed 6000 feet in height.

Secondary (?) formations prevail over the northern and eastern sections of the island, and patches of tertiaries are met with locally along the coasts. Of the tertiary deposits there are two well-defined basins that have been subject to some examination. One occupies the valley of the Lagoons on the south side of the island; it extends from the Bay of Neyba to Port au Prince, and likewise occupies a large portion of the Central Plains in that vicinity. The other, towards the north, embraces the valley of the River Yaqui, from Santiago to Manchineel Bay, beyond which it may be traced fringing the coast until it approaches Cape Haytien, a distance of above 100 miles.

This latter basin will be the object of the present remarks. See Map, fig. 1.

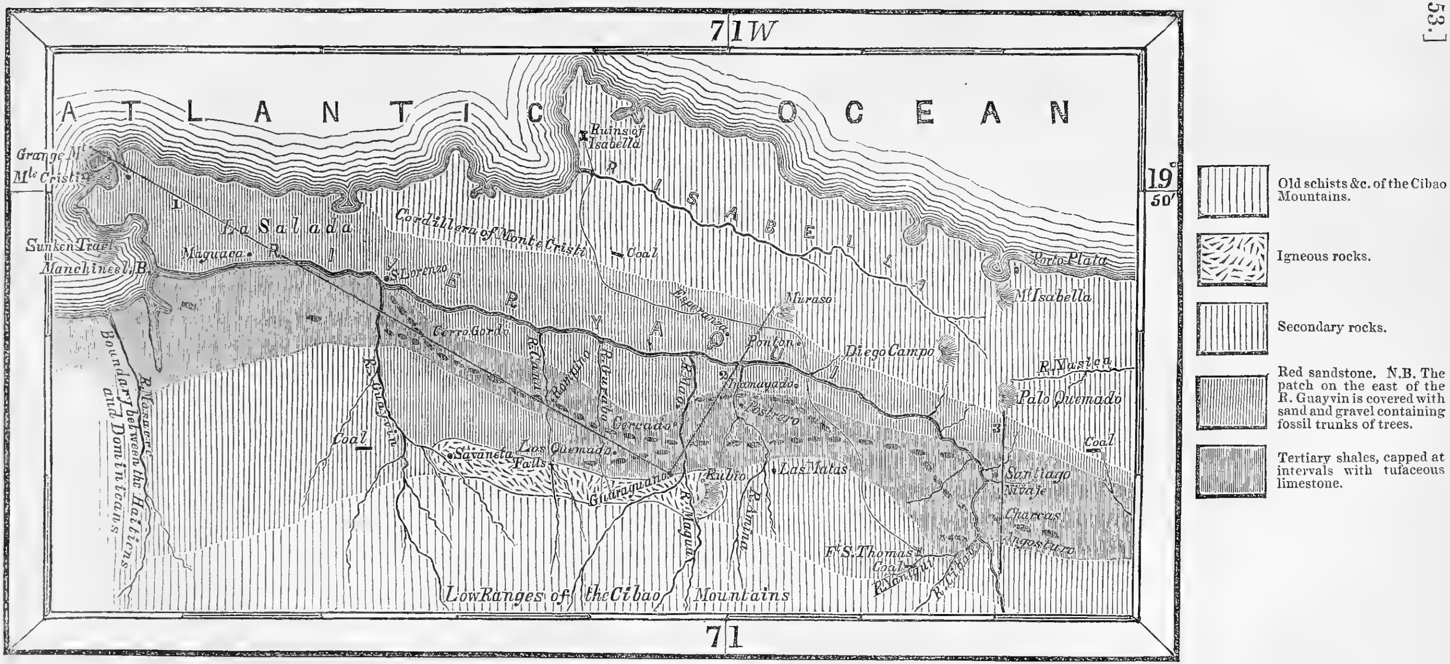
The valley of the Yaqui is bounded on the north by the cordillera of Monte Christi, and to the south by the Cibao Mountains. The substratum is composed of an unfossiliferous red sandstone, and the entire distance from Santiago to Monte Christi, about eighty miles, may be considered as an inclined plane or continuous sheet of sandstone. The stratification of this sandstone, although horizontal in some places, is in general very discordant, and often completely broken up by anticlinal axes†. At Ponton the dip is 25°, W. by N.; at Esperanza, some four miles to the westward, it is 25°, S.W. by S.; near Rompino the dip is 30°, N.N.W.; and at St. Lorenzo 45°, S.S.W. On the heights near Monte Christi, three miles from the Grange Mountain, it is 17°, N.E. by N.; under the Grange it is 7°, N.W. by N.

This sandstone protrudes in small irregular hills, scattered over the plain and more or less modified by the effects of denudation; and, being but scantily covered with alluvium, it forms a very dry barren district. These small elevations, however, give it an undu-

* For some remarks on the geology of the mountains of San Domingo, see also Schomburgk's Visit to the Valley of Constanza, Athenæum Journal, No. 1291. p. 797 *et seq.*

† It is a question, whether the disjointed state of the sandstone may not have some relation to the influence of those tremendous earthquakes to which this district is subject.

Fig. 1.—*Geological Map of a portion of the Province of Santiago, in the northern part of the Island of San Domingo.*



Note.—The Hills of Samba are not named on the Map; but they are indicated by the line of patches of tufaceous limestone running from San Lorenzo to Angostura.
×××× Ancient coral-reef.
From the Ruins of Isabella to Fort S. Thomas (lately discovered by the author) is laid down the line of route taken by Columbus on his first expedition into the interior of the Island.
N.B. Las Charcas and La Angostura should be more to the westward, and on the bank of the river.

lated appearance. The thickness of this sandstone cannot be less than 500 feet, and it is underlaid by a large development of conglomerates and a coarse gritstone, that crop out at the foot of the Monte Christi range of mountains, but no fossils have as yet been detected in them.

The River Yaqui takes its rise in the Cibao Mountains, and, pursuing a southerly course, meets the Tertiary beds near Santiago, which are here cut through, leaving on either hand perpendicular cliffs nearly 200 feet high; it then turns suddenly to the westward, and continues its way through the entire length of the sandstone plain, fringed on both its banks by a rich alluvial soil, averaging above two miles in width.

The height of the Monte Christi range is estimated at 3500 feet in the vicinity of Santiago, and its southern flanks are chiefly composed of a compact limestone affording good marble. This cordillera gradually diminishes in height as it approaches Monte Christi, where it terminates in low hills of shale and sandstone.

Coal (lignite) appears in the Monte Christi Hills at about long. 70° 32′ and long. 71° 7′, W. of London, and at other places along the range.

At some distance from the western extremity of this cordillera, and at the northern point of Monte Christi Bay, is the Grange, a steep, isolated table-mountain, above 900 feet high, in the same line as the cordillera, though of a newer formation. This mountain, as an interesting outlier, I shall revert to hereafter.

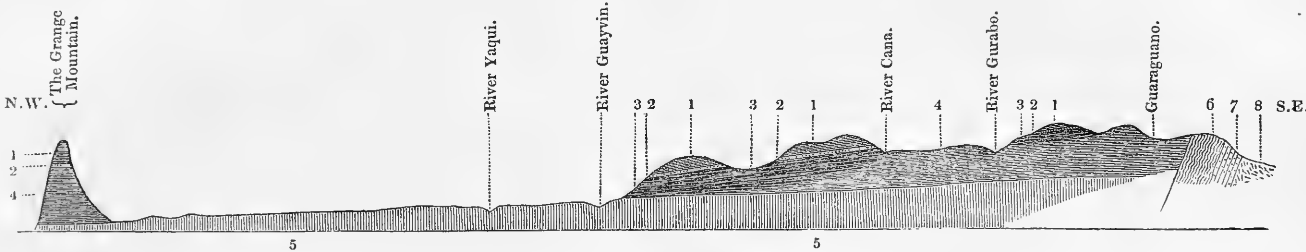
The Cibao Mountains, on the south of the River Yaqui, are chiefly made up of granite, greenstone, porphyry, quartz, chloritic schists, and other crystalline rocks.

Secondary (?) and metamorphic rocks skirt the Cibao Range at Las Matas and to the south-east; and again from between the Samba Hills and Savaneta to the westward. On this side of the Yaqui Valley coal occurs on the River Yanique, and about 7° W.N.W. of Savaneta.

Upon the extensive sheet of sandstone that fills the interval between the two ranges of mountains just described, the Tertiary beds of Santiago have been deposited (see Map and Sections, figs. 1, 2, 3, 4). Subsequently, a very considerable portion of these deposits has evidently been stript off by denudation, particularly from the northern and western parts of the valley. At the eastern extremity or apparent head of the basin, near the town of Santiago, they are tolerably perfect, and fill up the plain from one range of mountains to the other. (See fig. 4.)

The principal member is a bluish or greenish sandy shale, more or less affected by the colour of the neighbouring rocks from which it appears to have been derived. Occupying a central position along this blue shale, and following more or less the direction of the Samba Hills, is a yellow calcareous shaly deposit of the same age as the shale, and in some places covering, and in others interlacing itself with it; but evidently derived from a distinct source. This yellow deposit has been satisfactorily traced from the head of the basin to

Fig. 2.—*Section* (*No.* 1) *from Guaraguano to the Grange Mountain; passing longitudinally through a portion of the valley, and along the line of the Samba Hills.* Length about 50 miles.

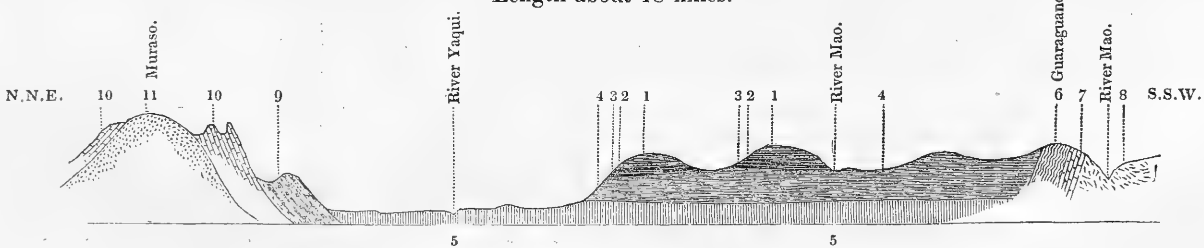


1. Tufaceous limestone.
2. Shingle bed.
3. Argillo-calcareous shales.
4. Blue and green fossiliferous shales.

} Tertiary.

5. Red sandstone, unfossiliferous.
6. Micaceous schist.
7. Limestone.
8. Greenstone.

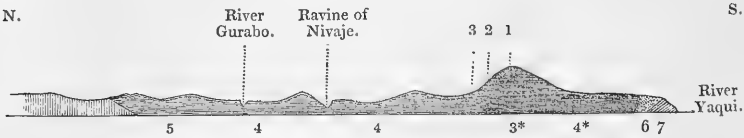
Fig. 3.—*Section* (*No.* 2) *from the River Mao, south of Guaraguano, to the Muraso Mountain; passing across the valley.* Length about 18 miles.



1—8, as in Fig. 2. 9. Conglomerates, grit, and lignite. 10. Compact limestone, affording marble. 11. Red sandstone, unfossiliferous.

the Grange Mountain, where the two deposits are very clearly visible in the sea cliff. (See fig. 7, p. 126.)

Fig. 4.—*Transverse Section* (*No.* 3) *from near the junction of the Rivers Yaqui and Cibao, South of La Angostura, to the Palo Quemado Mountain.* Length about 9 miles.



1. Tufaceous limestone.
2. Shingle bed.
3. Argillo-calcareous shales.
3*. Do., modified.
4. Blue shale.
4*. Dark shale.

(1–4*: Tertiary.)

5. Red sandstone,—dip 25° S. by E.
6. Conglomerates.
7. Dark flaggy sandstone and bituminous shales,—dip 33° N.N.E.

The lower beds, made up of these two shales, in some places 600 feet thick, are covered by a layer of shingle, consisting of pebbles of many kinds of rocks, some of them 18 inches in diameter, and more or less stained by oxide of iron. This conglomerate is of variable thickness, from 1 to about 10 feet, and the surface of the shale on which it reposes has in many places been eroded into cavities which are filled by the conglomerate. Lastly, this shingly conglomerate is covered by a tufaceous* limestone at least 300 feet in thickness. (See Map, and figs. 5 & 6, p. 124.)

The shales have a general dip of from 5° to 7° to the N.N.W.,

* Mr. H. C. Sorby, F.G.S., has most kindly supplied the following note:—The term "tufaceous" applied to this limestone, on account of its quasi-vesicular and roughly crystalline appearance, is inaccurate. The physical composition of the coarser-grained specimen from the Grange is—

Entire and fragmentary shells of a discoidal foraminifer	40·0
Fragments of two or three species of corallines	12·0
——— of coral	2·0
Entire and fragmentary foraminiferæ, of several species, smaller than the above	1·5
Crystalline matter surrounding the above, no doubt chiefly derived from decayed corallines and foraminiferæ	41·4
Empty cavities due to segregational removal	3·0
Peroxide of iron	·1
	100·0

The discoidal foraminiferæ above referred to are small, being from $\frac{1}{20}$th to $\frac{1}{30}$th of an inch in diameter, and hence are not readily recognized until seen in a thin section. Some of the fragments of corallines are quite rounded, so that, if their structure were not attended to, they might be mistaken for oolitic grains. There are no fragments which can be referred with certainty to the shells of mollusca. What was no doubt originally fine granules of decayed corallines and foraminiferæ, surrounding the fragments, has become crystalline, but not of coarse grain; and during this process the empty cavities have been formed, which in some parts are much more numerous than stated in the analysis; and the structure of some of the fragments has become obliterated. The finer-grained specimen from the same locality is composed of much the same material in a more finely comminuted state, and is imperfectly consolidated. Independent, therefore, of any other facts than those revealed by the microscope, I should be led to consider this limestone to be a marine deposit of a warm climate, in some respects analogous to those now taking place near the West Indian coral reefs. [July 18, 1853.]

but the tufaceous limestone, which has afforded no satisfactory lines of stratification, is presumed to be horizontal.

These beds always maintain the same relative position and contain the same group of fossils; and the Grange Mountain, the only outlier of shale on the north bank of the River Yaqui, exhibits a similar arrangement. The body of the mountain is composed of the blue shale covered by the tufaceous limestone in a tabular mass, and these are separated by the intercalated bed of shingle. At the western extremity of the Grange is the cliff above alluded to, that presents so interesting a section of the interlacing of the yellow and the blue sedimentary deposits (fig. 5). Upon the south face of the mountain the line of the two shales may be distinctly traced by the difference of the prevailing vegetation. The blue shale favours the growth of a kind of coppice, while the yellow shale is thinly covered with tufts of coarse grass.

I have tried to explain to myself how these two different kinds of sediment could have been deposited contemporaneously, and I venture to suggest the following explanation. The valley of the Yuna, to the eastward of Santiago, is, geographically speaking, a continuation of the valley of the Yaqui, and also contains tertiary deposits. At the time of the formation of the tertiary beds of the Yaqui Valley, these two valleys were in all probability one continuous sea or narrow strait, contracted about the middle. The same Equatorial current from the eastward that now prevails must then have existed, which, setting through the narrow strait, gradually silted it up with detritus from the surrounding mountains, while a current (possibly a river-course) from the southern side of the head of the basin furnished contemporaneously the yellow calcareous sediment.

As the shales gradually attained the surface, they were covered by shingle transported from the central chain of mountains; and submersion taking place, it is presumed that the same source whence the former calcareous sediment proceeded, being somewhat modified, then continued to supply the tufaceous limestone deposit; and which, I would suggest, might have been derived from a vast coralline formation to the south-east, which will be reported upon at a future day.

The blue shales may be distinctly traced in contact with the chloritic schists and secondary rocks along the south-eastern limits of the basin (see figs. 2, 3, 4); but they gradually thin off along their northern edge from Santiago to the westward from the effects of denudation, and they now appear as a narrow band, partially capped by the tufaceous limestone, which forms the chain of hills, called the Samba, intermediate between the two mountain ranges of Monte Christi and the Cibao.

That these tertiaries formerly covered the whole plain is very apparent on comparing the structure and formation of the Grange with the hills of Samba. Additional testimony of the extent which these tertiaries have occupied exists in the abundance of tertiary fossils strewed over the surface of the sandstone plains, and found imbedded in silt apparently derived from the destruction of these strata.

The formation of these beds seems to have been affected by processes even now in action, for in the environs of Santiago, or at least

in some of the ancient bays in that neighbourhood (now a thousand feet above the sea), a great variety and mixture of fossils are met with in compact seams, very similar in condition and general appearance to the shells, &c. now thrown up in the bay of Monte Christi, eighty miles distant, after a ground-sea.

The district of Santiago is indeed of a very interesting character, and rich in fossil remains. Between Fort St. Thomas* and the junction of the River Cibao with the Yaqui is a high mountain-ridge, called the Armasigo, along the crest of which may be traced, for above two miles, a continuous line of coral, evidently the remains of an old reef, which from its solidity has apparently served as a cap or defence, and preserved this ridge from denuding forces until the surface was fairly raised and out of danger.

I may also observe, that on the River Amina the blue shale, referred to as resting generally upon the sandstone and older rocks, lies upon unfossiliferous mottled clays.

Notes upon the localities.

Santiago (River Yaqui).—Tertiary formation: beds of blue shale,—dip S.E., $\angle$ 9° to 11°.

Santiago is the capital of the Province of Santiago, it contains about 5000 inhabitants, and stands upon a high bluff of the River Yaqui. The bed of shale of which the bluff is chiefly composed is compact and has a jointed structure. The partings run to the S.S.E. and E.N.E.

The River Yaqui springs from the northern flanks of the Cibao Mountains; its course is northward as far as Santiago, cutting its way through the tertiary beds; it here turns suddenly to the westward, leaving a spacious platform (the site of the town) at an elevation of 150 feet above the river.

Fossils are not very abundant, being confined to a few narrow seams, 5 or 6 inches thick, intercalated in the shale. These seams are composed of shells, both entire and in a comminuted state, mixed with fine sand, and have the appearance of a recent beach after the effects of a ground-swell from the ocean; very similar to what is seen in the Bay of Monte Christi occasionally at the present day.

These beds suffered denudation to a certain extent after having been tilted, and were subsequently overlaid by patches of coarse shingle, the origin of which is not yet satisfactorily determined. They cross the plain from the Cibao to the Monte Christi Range, and gently thin off to the westward. They afford a soil for the purposes of agriculture only in low humid localities. The fertility of the rich plantations to the east of Santiago is entirely due to a subsequent argillaceous deposit which is highly retentive of moisture, and is now covered by a deep vegetable mould.

Nivaje.—This is the name of a deep narrow ravine, to the S.E. of the town of Santiago, which exposes interesting sections of the blue shale, &c. It affords mineral waters; which spring from a bed of

* The site of this fort was only lately discovered. It was the first military post established in the interior, for the subjugation of the New World. Its position and the track of Columbus from the coast are shown in the Map, fig. 1.

sandstone, exposed by the deep cutting of the ravine. A few fossils were here collected bearing the usual character.

The large *Ostrea Virginica* is here abundant, and, from the prevalence of fossil wood in detached masses, this locality seems to have once formed a small bay or the estuary of a river. The wood is met with in different stages of carbonization, much of it is permeated by sulphate of lime, and some pieces are entirely riddled by *Teredines*. The strata along the ravine are much disturbed.

Las Charcas.—Beds of blue shale: dip N.E. by E., ∠ 7°.

Ascending the River Yaqui from Santiago to the southward, at the distance of three or four miles over the blue shale, is the Farm of Las Charcas.

The cliffs of the river are full as high here as at Santiago, but they are richer in fossils, and the same fossiliferous seams prevail.

The upper parts appear to have been denuded, and afterwards covered with coarse shingle, and at a still later period a yellowish marl was deposited on the latter.

The shale here, as at Santiago, assumes a jointed structure; the prevailing direction of the partings is S.E. by S., E. by S., and S.W. by W.

Hills of Samba (eastern extremity).—This range of hills crosses the River Yaqui a short distance south of Las Charcas, the river being confined to a very narrow passage between perpendicular walls of a hard calcareous rock in alternate seams with a soft ferruginous sandy shale, dipping north ∠ 23°. These seams appear to be modifications of similar strata noticed at Cercado, and of an argillo-calcareous shale that comes out at the Grange,—a band that follows the Samba Hills throughout their whole course.

Impure ferruginous sandy calcareous shale of much the same nature covers these seams with a dip N. by W. ∠ 10° to 14° It is traversed by perpendicular joints, running N. and E.S.E. The hill is covered by tabular masses of tufaceous limestone.

La Angostura.—Black and yellow shales,—dip N.E. ∠ 7°.

This place appears to have once formed a deep bay or corner of the tertiary basin. The cliffs of the Yaqui continue to have an average height of above 150 feet, but the component materials are somewhat modified, being formed of a soft blackish shale, in some places almost composed of fine black sand. This bed contains fossils, both disseminated and in thin indurated seams. The shale is also more or less mixed with gravel in the upper parts, and is covered by the soft yellow sandy calcareous shale of Samba, also fossiliferous; but the fossils, as is usual in all ferruginous strata, are in a bad state of preservation. The bed of yellow shale here is about 50 feet thick. Corals are small and rare.

Beyond Angostura, and at the mouth of the River Cibao where it joins the Yaqui, the tertiary beds are in contact with secondary rocks (perhaps of the Carboniferous system), which consist of dark sandstone flags, alternating with black bituminous shales in narrow seams, dip N.N.E. ∠ 33°. No fossils were observed.

Postrero (River Amina).—Beds of blue shale,—dip N.W. by N. ∠ 5°.

The fossiliferous shale is well exposed in the deep cuttings of the River Amina at this place. The fossils are altogether disseminated.

Fish teeth are frequently found upon the surface of the shale.

Cercado (River Mao).—Beds of blue shale dip N.W. by N. 5°. Fossils disseminated.

This is merely the name of a locality where a few farm-houses are built upon the banks of the river.

A short mile southward from the houses, up the River Mao, the blue shale is exceedingly well displayed in a cliff, 200 feet high from the surface of the water, which may be termed the main cliff. (Figs. 5, 6.)

Fig. 5.—*Section of the Cliff at Cercado, on the River Mao.* Height 200 feet.

[The summit at A is about 900 feet above the sea-level.]

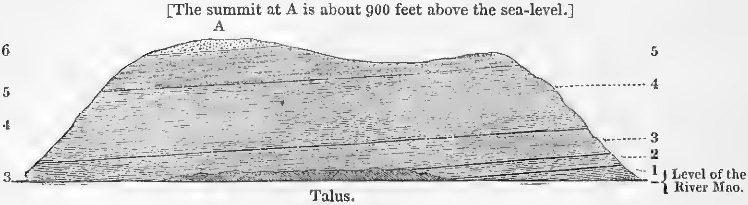
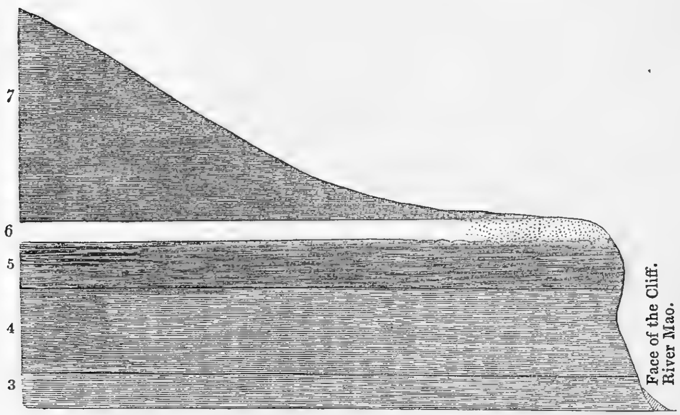


Fig. 6.—*Section of the Cercado Cliff, transverse to Fig. 5, at* A, *and of the rising ground inland.*



1. (10 feet exposed) } Bluish sandy shales, fossiliferous.
2. 20 feet.
3. 50 feet.
4. 90 feet. Do., without fossils.
5. 50 feet. Argillo-calcareous shale, with fossils.
6. from 10 to 20 feet, Coarse shingle.
7. 300 feet, Tufaceous limestone.

(1–6: Dip 5°, N.W. by N.)

The shale is divided by partings or narrow bands, a few inches thick; of more compact and hardened materials, which stand out in strong relief along its nearly perpendicular front. Separate collections of fossils were made from the different beds.

Bed No. 1 is exposed only to the depth of 10 feet, and cannot be traced beyond the main cliff owing to extensive denudations. No. 2. About 20 feet thick. No. 3. About 50 feet thick.	The fossils are disseminated throughout the shales.

No. 4. About 90 feet thick; composed of similar blue shale, without fossils.

No. 5. About 50 feet thick. Hard ferruginous bed. Fossils decomposed.

The upper surface of section No. 5 has evidently suffered denudation. No. 6 is composed of shingle from older rocks, the size of the boulders being from less than an inch to 18 inches in diameter. This shingle is more or less tinged by the red oxide of iron, and has a thickness of from 10 to 20 feet and upwards.

No. 7 is a thick tufaceous limestone that covers the whole.

In another cliff, a short distance to the north of Cercado, the lower beds are hidden. No. 5, however, is here very conspicuous, but it is more siliceous and gritty, and in some places excessively hard, and some of its fossils are in better preservation, than at Cercado.

Los Quemados (River Gurabo).—Beds of blue shale;—dip N. by E. $\angle 5^\circ$.

The fossils from this place are identical with those of Postrero and Cercado, merely offering some variety in the species. Though the dip of the strata is here easterly, the same blue shale prevails, as likewise the superior argillo-calcareous shale, but it is much thicker than at Cercado, and is rather a dense mass of broken coral imbedded in clayey matter.

Hills of Samba (Tufaceous limestone).—The locality and formation of this range of hills have been already described. They are capped by a deposit of tufaceous limestone with its peculiar fossils.

The stratification of this tufaceous limestone is very obscure and indistinct. I have never yet determined the dip satisfactorily, perhaps from not meeting with it in favourable positions. It apparently covers the inferior strata conformably, but I have reason to expect that it will be found to be more horizontal. I suspect there has been an oscillation and denudation to some extent, between the deposit of the shale and the limestone, which future investigations may ascertain.

On the summits of these hills the surface is crumbled and broken, and no good specimens of organic remains are to be found; the remains of Mollusca and Corals are met with, but they are all in a very decomposed state. It was only at the western extremity of these hills (in the lee of the old current), where the limestone is nearly in contact with the red sandstone, that good fossils were obtained. Here I ascertained the dip to be W. $\angle 3^\circ$.

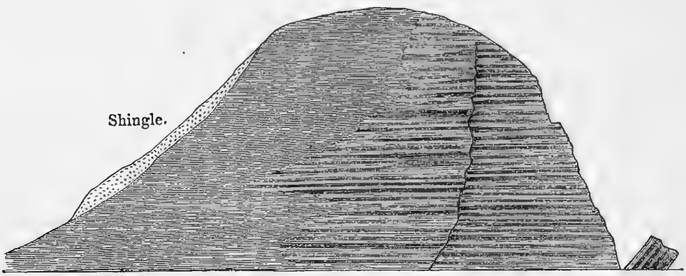
The Grange.—This is an isolated table-mountain, the structure of which for a long time I could not satisfactorily explain. After an examination of the Samba Hills, however, it was suspected to be a part of the same formation, and further investigations confirmed this opinion.

The northern face, which stems the angry surges of the Atlantic, is nearly perpendicular, and affords ample scope for observation. The base is of red sandstone,—dip N.W. by N. ∠ 7°. It is covered conformably by the blue fossiliferous shale, and this is overlaid by the tufaceous limestone.

The summit-ridge is extremely narrow; it scarcely appears to be 20 feet across, and is crowned with an almost impenetrable copse of thorns, growing out of the interstices of the solid limestone rock. It is said that this circumstance induced Columbus to give it the name of Monte Christi. The French afterwards gave it the name of La Grange, from its resemblance at a distance to an enormous barn, by which name it is now more generally known. The miserable vestige of a once flourishing town of above three thousand inhabitants, built at the foot of it, is all that retains the name of Monte Christi.

The rock-specimens from the different beds of the Grange, when compared with those from the Hills of Samba at Cercado, appear to be as nearly similar as could be expected for the distance they bear from each other. The dip of the beds of the Grange is almost identical with that of the beds of Postrero and Cercado. The blue shale appears to be about 800 feet thick, covered by about 200 feet of limestone in a tabular mass.

Fig. 7.—*Section of the Cliff at the western extremity of the Grange Mountain, showing the interlacing of the shales.*



1. Blue sandy shale, fossiliferous.
2. Ferruginous calcareous shale, alternating with argillaceous sandy shale; fossiliferous.

The cliffs at the western extremity of the Grange display an interesting intercalation of the blue and the yellow shales (see fig. 7): the latter is argillo-calcareous, and is, apparently, a large development of what at Cercado is a thinner bed of 50 feet thick; it appears, also, tc be a modfied form of the calcareous shale so largely developed at Angostura.

Fossils from the Sandstone plains.—These fossils were collected at Inamagado, Esperanza, Rompino, Cerro Gordo, San Lorenzo, La Salada, and Cana.

They are found scattered upon the surface of the sandstone plain of the district of Santiago, usually half-buried in silt or coarse sand, sometimes in vegetable mould.

These fossils may be considered more or less as erratics. They seem to appertain chiefly to the remains of pre-existent strata that once covered the plain.

Some belong to the blue shale, others to the tufaceous limestone, and many may be recent. They are generally in a bad state of preservation, being broken and worn, as if by attrition.

At Inamagado there are traces of the blue shale which has not been entirely denuded; consequently the fossils from thence are more numerous, and approach more in character to those of Postrero and Cercado. Still there is a difference, and it may be remarked with regard to these fossils from the sandstone plain, that some particular species more or less predominate to the exclusion of others, some of which seem to be peculiar to each locality, however near they may approach to each other. These several local collections were hastily made during marches and military service, and for many reasons can scarcely be regarded as more than approximately correct representatives of the fossil faunas of these districts.

Inamagado.—This is merely the name attached to a tract of grazing farms. Here, as I have already observed, are traces of the blue fossiliferous shale; there are also traces of the upper bed No. 5 of Cercado (argillo-calcareous shale), and there is a similarity in many of the fossils to those of Postrero and Cercado. The angle of dip was not satisfactorily obtained here.

Esperanza.—The fossils at this place are scarce and in a bad state of preservation. Numerous detached blocks of coarse sand, more or less coherent and containing fossils, lie scattered over the surface. They do not belong to the sandstone rock *in situ*, upon which they immediately rest. Some of these specimens of fossiliferous grit appear to be identical with bed No. 2 of the more northern cliff at Cercado. Dip of the sandstone strata S.W. by S. $\angle$ 25°.

Rompino.—This place is situated on the River Cana, where it issues from the deep narrow channel it has cut through the Samba Hills.

The fossils from this place appear to be of a mixed character, having reference both to the blue shale and the tufaceous limestone; some are perhaps peculiar to the spot. The argillo-calcareous shale of Cercado prevails here,—dip N.N.W. $\angle$ 10°.

Cerro Gordo.—The specimens collected here form a group differing in appearance considerably from all the others. I noticed, however, a large Coral, similar to one taken from the tufaceous limestone at Rompino, and there may be other analogies. The specimens were taken from a mound very much like an old coral-reef; with sandstone hills in the vicinity.

San Lorenzo.—This is the name of a small village whose plan I traced since the war, to accommodate the border population, forced to retire from the vicinity of the enemy. It is now the head-quarters of our northern line of cantonments.

The specimens from this place were gathered upon sandstone hills two or three miles to the north of it. The strata of these hills dip S.S.W. $\angle$ 45°. Considerable quantities of selenite are mixed with the fossils. It is met with in the form of veins, and also massive, in the shales and silt that overlie the sandstone superficially.

La Salada.—These specimens also have a general aspect differing from that of the other local groups; but like all the others, they are either found in silt or vegetable mould, or lie exposed upon the surface of the sandstone amid straggling tufts of grass and stubble. This fact explains why most of the corals and many of the shells sent on a former occasion seemed to have been taken from a vegetable soil, and were suspected to be recent.

The sandstone *in situ* has no fossils, wherever I have met with it.

There is no doubt that the entire plain, from Santiago to Monte Christi, is continuously covered with various interesting fossils, that would amply reward the curiosity of such as have the command of time and means to make the necessary researches.

River Cana.—Red sandstone in horizontal strata.—The bed of this stream, from the Falls to Rompino, is very narrow, deep, and laborious to investigate. It has cut through the superincumbent loose materials, apparently composed of the debris of sandstone and gravel that compose the plain, and pursues its course over a clean sheet of sandstone rock.

Excepting from below the Samba Hills, which could not be examined, the blue shale has either been stripped off, or was not deposited here, thinning off in quantity as it approached the locality between the Sambas and the Falls; of which there are indications at Los Quemados, as well as of an increase in the argillo-calcareous shale No. 5 of Cercado, which is here very prominent.

The few fossils attributed to this locality were taken chiefly from the sandstone plain of Savaneta. Large Conchifera of the family of *Arcacea* are in great abundance; they cover the surface in patches of compact seams.

The falls of this river are caused by the obstruction of a mass of igneous rock, over which the stream has a perpendicular descent of above 100 feet.

Savaneta.—The plain between Savaneta and the Hills of Samba is of red sandstone in horizontal strata, covered conformably by some seams of loose sand and gravel.

This plain near San Jose abounds in fossil trees, whose entire trunks lie extended on the surface; many of them measure above 20 feet long, and 12 inches in diameter. They appear to have been jointed. The plain is also abundantly covered with fossil Conchifera, as already noticed under the head of *River Cana.*

Savaneta is another village I traced, on the skirts of the Cibao Range. There is here an oblong patch of igneous rock extending from the River Guayuvin to near the Amina.

From Savaneta to the south-west, approaching the Cibao Mountains, the fundamental strata follow each other in the following order:—Mica schist associated with quartz, Limestone, Conglomerates, Serpentine, Quartz, Chloritic schists, and Gneiss, all in nearly perpendicular strata,—dip N.N.E. The country south of Savaneta is covered with pine-forests.

Monte Christi Mountains.—The limestone of the Monte Christi Cordillera is mostly in large detached masses on the southern face of the mountains; I have met with no fossils in it, and the stratification is very obscure.

I crossed the Range only on one occasion, and mounted to the summits of different peaks; they are as bare as sugar-loaves. It would require much time to be spent in these mountains in order to investigate them satisfactorily.

The following are the approximative heights (above the sea) of some of the more important localities:—

Mount Isabella de Torres near Porto Plata	2400 feet.
Mount Diego Campo, Monte Christi Range	3500 ,,
Muraso, Monte Christi Range	2800 ,,
Town of Santiago, less than	1000 ,,
Guaraguano	2400 ,,
The Grange	1000 ,,
High Peaks of the Cibao Range	6000 ,,

Notes on the Fossil Mollusca *and* Fish *from* San Domingo. By J. C. Moore, Esq., V.P.G.S.

The rich addition which Colonel Heneken has lately made to the collection of fossils sent over by him in 1848, greatly extends our knowledge of the Tertiary deposits of San Domingo; and, having been made with great care, and the fossils from different localities having been kept distinct, it enables us to correct one or two inaccuracies in the former Report*. The fossils are to be considered as of three classes: 1st, those from the silt covering the sandstone plain; 2nd, those of the tufaceous limestone; and 3rd, those of the green (or blue) shales.

The first may at present be dismissed from consideration; they consist of rolled specimens of the older tertiary fossils, mixed with recent shells and corals of West Indian species, imbedded in silt and gravel. It was from these deposits that three of the shells of the former collection were derived, and which were erroneously attributed to the older tertiaries. These shells are *Columbella mercatoria, Lucina Pennsylvanica,* and *Lucina tigerrina.*

2nd. *Tufaceous limestone.*—The fossils from this deposit are principally Corals, of which there are five species: there are eight species of Mollusca, of which one only (*Pleurotoma virgo*) has been identified with a living species. The following is the list:—

Pleurotoma virgo, also found in the green shales.	
Cassis sulcifera, *Sowerby,*	do.
Venus, one sp.	
Spondylus bifrons, *Sowerby,*	do.
——, new sp.	
Arca patricia, *Sowerby.*	
Ostrea Haitensis, do.,	do.
Chama, new sp.	

3rd. *The green shales.*—I readily perceived, on examination, that the green shales of Santiago, Nivaje, Postrero, Las Charcas, Cercado, and the black and yellow shales of Angostura were all of one formation, from the great proportion of fossils common to all the localities; and Colonel Heneken had arrived at the same conclusion, from their stratigraphical position. The fossils consist of the teeth

* Quart. Journ. Geol. Soc. vol. vi. p. 39 *et seq.*

of 4 species of Fish, a Crab, 163 species of Mollusca, an Echinoderm, and 10 species of Corals, the greater part in a fine state of preservation. The Corals have been examined by Mr. Lonsdale, who, in spite of delicate health and the many demands upon his time, is always ready to lay the stores of his information at the disposal of this Society. His report accompanies Col. Heneken's Memoir.

Sir Philip Egerton was so obliging as to examine the Fish teeth, and he identifies them with the following species:—

Carcharodon megalodon.	Hemipristis serra.
Oxyrhina xiphodon.	Odontaspis dubius.

The *Carcharodon* and the *Hemipristis* are quoted by American geologists as occurring in the Eocene formations of South Carolina, Georgia, and Maryland; and also in the Miocene formations of Maryland and Virginia. They are all four found in the Malta beds. Of these, 14 are believed to be recent, or less than 9 per cent. In the former list, 13 recent shells were enumerated; but from this number 3 are to be deducted, which had been erroneously attributed to this formation, as before mentioned. Two others, which were looked upon by Mr. Sowerby as varieties of the *Phos Veraguensis* and *Cancellaria reticulata*, are not considered identical with those shells by the naturalists who have had more perfect specimens to judge from, and are therefore also deducted. There remain 8, to which 6 more are to be added from the collection now sent. The following is the list:—

	Habitat.	*Fossil in*
Triton variegatus	W. Indies.	
—— femoralis	do.	
—— gemmatus	Philippines and West Australia.	
Turbinellus ovoideus....	W. Indies.	
—— infundibulum	do.	American Miocene.
Terebra flammea	do.	
Oliva hispidula	do.	
Pleurotoma virgo	?	
Nassa incrassata	Mediterranean.	Bordeaux, Dax.
Natica sulcata	W. Indies.	
Bulla striata	do.	Montpellier.
Chama arcinella	do.	American Miocene.
Venus puerpera........	Indian Seas.	
—— Paphia	W. Indies.	Vienna.

It was mentioned in the report of 1850, that Mr. Sowerby, who examined the Mollusca, was much struck by the close resemblance which many bore to shells now living in the China Seas and the Pacific. That resemblance is maintained in the collection lately received. After a close comparison with the shells of the British Museum, Mr. Cuming's, and other private collections, in which I was kindly assisted by Mr. Searles Wood, Dr. Baird, and Mr. Cuming, in many cases the nearest analogue was from those seas. In addition to the cases mentioned by Mr. Sowerby, the following may be enumerated:—

Cassis, scarcely distinguishable from *C. abbreviata*, Acapulco.

Malea, closely resembles *M. ringens* (Kiener), Coast of Peru, if it be not identical.

Columbella, very like *C. pavona*, Gulf of California.

Murex, nearest to *M. pinnatus*, China Seas.

Conus, intermediate between two closely allied species in Mr. Cuming's Museum, from the Philippines.

The genus *Phos*, of which several species are known in the Bay of Panama and none in the West Indies, is here represented by four species, all closely related to shells of the Pacific.

Venus, nearest to *V. Gnidia*, California.

Arca, a large species very like *A. grandis*, Bay of Panama: no large *Arca* is now found in the Atlantic.

A tube of a bivalve shell (the *Septaria* of Lamarck), which during a part of its growth is divided longitudinally by a septum into two tubes: only one living species is known, the *Teredo giganteus* of Rumphius, which lives in the Indian Ocean.

With the exception of those few shells found both in a recent and fossil state, we were not able to identify a single shell with any known fossil.

Of American formations, the South Carolina beds, described by Mr. Conrad in the Journ. Nat. Sciences, Philadelphia, vol. i., present the nearest analogies, but no specific identifications. The Fauna of the West Indian seas in those remote times appears to have been as distinct from that of the shores of the United States, as it has lately been shown by Mr. Bland to be at the present day.

All the conclusions drawn from the former collection seem confirmed, now that the means of judging from the number of species* are nearly doubled: they are shortly these:—

1st. These beds contain Mollusca of which from 8 to 9 per cent. are now living.

2nd. The recent species are principally living in the adjoining seas.

3rd. Many bear a strong resemblance to shells now living in the Indian seas and the Pacific, and one or two appear to be identical.

4th. None are identical with American fossil shells, except two, both of which are also recent.

5th. The fossils which present the nearest analogies as a group are those of Malta and Bordeaux in Europe, and the Upper Eocene beds of South Carolina.

* The Mollusca of the Green Shales are referable to the following genera:—

Strombus	4	Mitra	6	Melanopsis	1	Tellina	6
Cassidaria	2	Fasciolaria	4	Bulla	4	Venericardia	1
Cassis	2	Turbinellus	7	Turritella	2	Cardium	2
Malea	1	Cuma	1	Natica	4	Corbula	1
Oniscia	1	Fusus	2	Turbo	4	Pecten	7
Typhis	2	Rostellaria ?	1	Bonellia	1	Pectunculus	4
Conus	13	Marginella	2	Trochus	1	Arca	2
Murex	3	Columbella	4	Solarium	1	Chama	1
Ranella (spire of)	1	Cancellaria	3	Dentalium	3	Spondylus	3
Triton	4	Pleurotoma	9	Siliquaria	1	Ostrea	1
Pyrula	2	Terebra	6	Vermetus	1	Septaria (*Lam.*)	1
Cypræa	4	Phos	4	Petaloconchus	1		
Oliva	4	Nassa	1	Sigaretus	1		163
Voluta	2	Cerithium	7	Venus	7		

6th. All the fish are identical with species known in formations classed as Upper Eocene or Miocene.

Note.—In addition to the *Foraminiferæ* mentioned in the former Paper (*l. c.* p. 40), Mr. Rupert Jones informs me that the following also occur:—

Frondicularia.	Dendritina.	Orbitolites.
Amphistegina.	Orbiculina.	Quinqueloculina, &c.

These are, for the most part, recent forms.

NOTE.—Since the above was written, Mr. G. H. Saunders, F.G.S., has presented to the Society a series of fossils found a few months since by Mr. J. T. Green in some shelly beds on the eastern side of the Isthmus of Panama, about $2\frac{1}{2}$ miles from the shores of Navy Bay, and at the height of about 15 feet above the Atlantic, in a cutting of the Panama Railway. Some of the shells are well-preserved, and others are in the condition of casts. The general aspect both of the fossils and of the rock strongly reminds one of the San Domingo specimens. On a cursory examination I find that there are above twenty species, and some of them unquestionably identical with the fossils collected by Col. Heneken in San Domingo. The following is a list of those of the best-preserved specimens that occur in both of the localities:—

Oliva cylindrica, *Sowerby*.
——, unnamed species.
Natica subclausa, *Sowerby*.
—— sulcata, *Desh.*
Malea, unnamed sp.
Phos, unnamed sp.
Strombus bifrons, *Sow.*
——, cast of unnamed species.
Murex Domingensis, *Sow.*

In addition to these, there are *Conus*, two species; one of which may be identical with a S. Domingo species.

Turritella, two; one of them closely allied, if not identical with, a S. Domingo species.

Venus, one.
Cardium, one; very like a S. Domingo species.
Tellina, one.
Sanguinolaria, one.
Ostrea, one; like a S. Domingo species.
Pecten, *Teredo*, &c.

Notes on the FOSSIL CORALS *of* SAN DOMINGO.
By W. LONSDALE, F.G.S.

THE corals, to which this memorandum refers, are limited, with four exceptions, to those originally labelled by Mr. Heneken "Nivaje" and "Tufaceous Limestone;" and the four have been included, because they bear every indication of having belonged to those deposits, with no signs of having been drifted. The collection of St. Domingo corals, most obligingly submitted to inspection by Mr. J. C. Moore, contains, however, two other interesting series, procured

by Mr. Heneken from the "Drift" of the Nivaje district, and from "the silt of the sandstone plains;" but neither of them has been examined further than was necessary to ascertain whether they include any species identical with those obtained directly from the regular deposits. In three instances approximate agreements have been detected. One of them is a *Placocyathus*? found in the Nivaje deposit, and its presumed analogue was derived from "the silt of the sandstone plains," which appears, from information kindly afforded by Mr. Heneken, to have chiefly resulted from denudated tertiary strata. The two other instances are a species of *Dichocœnia*, and a fossil seemingly allied to the *Mussæ gyrosæ*. They both belong to the "tufaceous limestone," and the supposed representative of the *Dichocœnia* was procured from the "silt;" but the coral provisionally referred to *Mussa* was discovered in the "drift" of Cerro Gordo. In these cases, however, the information yet obtained is insufficient to establish a specific identity; and, as respects the "drift" specimen, doubts are entertained if it had been previously derived from the limestone deposit.

It may be added, that the corals of the "drift" are, as a whole, distinct from those of the "silt of the sandstone plain," and, so far as the evidence extends, they bear more the semblance of the existing than of a tertiary fauna.

The fossils believed to be referable to the Nivaje shale belong to ten species, and are assigned absolutely or provisionally to the following genera, according to the recent classification of M. Milne-Edwards and M. Jules Haime:—

1. Placocyathus?, 2 sp.
2. Ceratotrochus?, 1 sp.
3. Flabellum, 1 sp.
4. Rhipidogyra?, 1 sp.
5. Circophyllia, 2 sp.
6. Astræa, 1 sp.
7. Pocillopora, 1 sp.
8. Undescribed genus referable to the Subfamily Eupsamminæ, 1 sp.

Of the seven named genera, six are stated in the 'Archives du Muséum d'Histoire Naturelle' (t. v.) to have tertiary representatives, namely *Ceratotrochus*, one eocene and three miocene species*; *Flabellum*, six? eocene, eleven? miocene, and four pliocene, besides three with no fixed tertiary epoch; *Rhipidogyra* and *Pocillopora* have one miocene species each, and *Circophyllia* one eocene, and *Astræa* nine miocene. Descriptions of the whole of these corals, except one uncertain generic determination, have been carefully consulted, but not a single identification with a Nivaje fossil could be established.

It may be not altogether useless to state, that, of the seven genera above mentioned, three—*Ceratotrochus*, *Rhipidogyra*†, and *Circophyllia*—do not appear to have yet been obtained in a living state; while the locality, whence the only described existing species of *Placocyathus* was procured, is unknown; the recent species of *Flabellum* are confined chiefly to the Indian Ocean and Chinese seas, and *Pocillopora* is stated by Mr. Dana to occur solely among coral-reef-areas;

* The genus of the eocene fossil is given doubtfully, and one of the miocene species is stated to occur also in a pliocene deposit.

† As limited in the 'Archives,' t. v. p. 57.

Astræa being the only genus which has ascertained representatives on the coasts of the West Indies. Not one of the Nivaje fossils could be identified with a described existing species of the genera to which they are believed to belong.

Tufaceous Limestone.—The corals believed to belong to this deposit are limited to five, and one of them, a fine specimen of *Caryophyllia*, is doubtfully labelled "Cerro Gordo"; but the attached matrix seems to be tufaceous limestone, and the fossil, though very liable to injury from friction, bears no signs of having been drifted. Only three of the five corals have been positively assigned to described genera, one of the others being possibly allied to the *Mussæ gyrosæ*, and the actual composition of the fifth has not been ascertained further than would admit of its being referred to the family *Astræidæ*.

The three established genera are *Dichocœnia, Caryophyllia*, and *Astræa*. The first does not appear to have any published fossil species, but a living one occurs on the coast of Cuba; *Caryophyllia*, as lately restricted by M. Milne-Edwards and M. Jules Haime, possesses two living West Indian species, with one tertiary, *Cary. Basteroti*, found at Dax; and a comparison of its characters, given in the 'Annales des Sciences Naturelles' by the palæontologists just cited, with the structures exhibited by the St. Domingo coral, has led to the inference that the two fossils are essentially distinct. As regards the *Astræa*, no identification could be established with any one of the nine tertiary species before mentioned. With reference to the recent *Dichocœniæ, Caryophylliæ*, and *Astrææ* found in the West Indies or elsewhere, no specific agreement with the "tufaceous" fossils could be effected by means of a comparison with published descriptions.

In conclusion, it may be stated, that the whole of the St. Domingo corals being considered distinct from those with which a comparison has been instituted,—and the inquiry has not been limited to any particular division of the supra-cretaceous series,—no definite inference can be drawn from them respecting the relative geological position of the Nivaje shale and the tufaceous limestone.

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2. *On the* Series *of* Upper Palæozoic Groups *in the* Boulonnais. By Robert A. C. Austen, Esq., F.R.S., Sec. G.S.

[*Vide infra*, p. 231.]

April 6, 1853.

John Mainwaring Paine, Esq., was elected a Fellow.

The following communications were read:—

1. *On the* Granitic District *of* Inverary. By The Duke of Argyll, F.G.S. &c. &c.

[The publication of this Paper is postponed.]

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2. *On the* Carboniferous *and* Silurian Formations *of the neighbourhood of* Bussaco *in* Portugal. By Senhor Carlos Ribeiro. *With Notes and a Description of the* Animal Remains, by Daniel Sharpe, Esq., F.G.S.*, J. W. Salter, Esq., F.G.S., *and* T. Rupert Jones, Esq., F.G.S.: *and an Account of the* Vegetable Remains, by Charles J. F. Bunbury, Esq., For. Sec. Geol. Soc.

Plates VII. VIII. IX.

The Palæozoic deposits of Bussaco are bounded on the west by newer deposits, which have been partly described by Mr. Sharpe: before entering upon the principal subject of this memoir some remarks are added which serve to connect his observations with those which follow here.

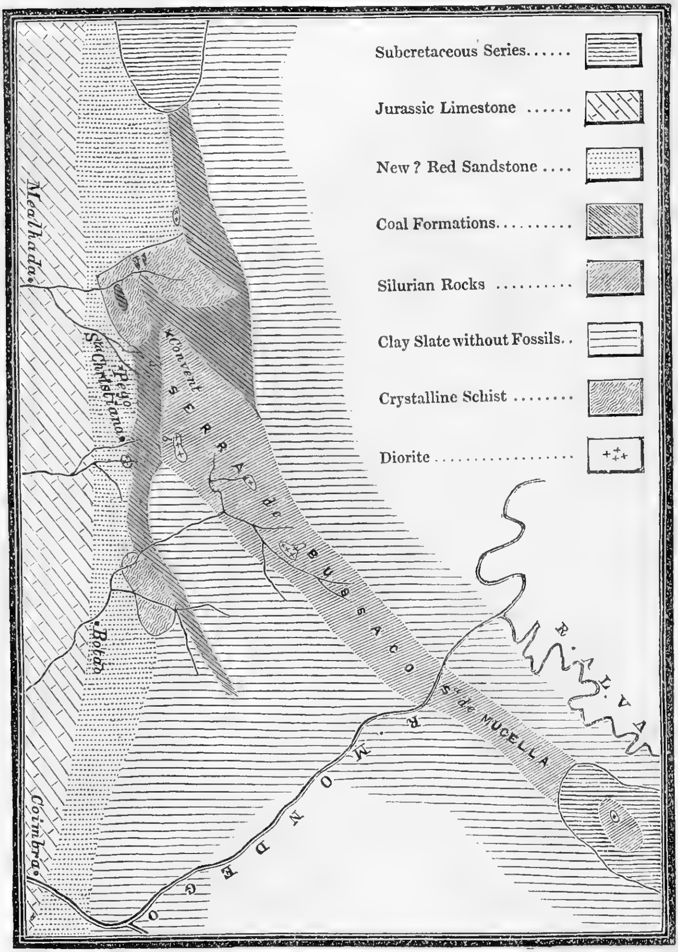
Jurassic Series.—In the Val de Gorgoraõ, half a mile north of Coimbra, is a limestone with many species of shells, the same as those of Mealhada, which probably belongs to the Inferior Oolite†. This rests on the limestone of Montarroio in Coimbra, in which were found the carapace of a Turtle and many shells absolutely different from those of the Jurassic rocks of this district; but it contains neither Ammonites nor Belemnites. The shells have some analogy to those found at Chaõ de Lamas and Cinco Villas, ten and eighteen miles south of Coimbra, which will be mentioned presently, one of which resembles *Posidonia minuta*, while others are probably *Mytili*.

Immediately below the above and resting conformably on the Red Sandstone, with which it contrasts strongly in colour and mineral characters, is a group of beds not exceeding five metres in thickness and of limited extent, observed at Lordomaõ, one mile north-east of Coimbra, in the Quinta di Varzea, and at Pereiros on the side of the road to Thomar, three miles south of Coimbra: the lowest beds are of a coarse grey sandstone, covered by a series of thin beds of fine calcareous sandstone of a dark yellow colour, alternating with yellow marl and grey and black shales; some of these beds are covered with very imperfect casts of shells of very few species.

* In November 1850 Senhor Ribeiro sent me an account of some beds through which he was engaged in sinking a shaft in search of coal at Santa Christina, ten or twelve miles north of Coimbra, on the west side of the Serra de Bussaco. The letter contained so much interesting geological information that I requested him to add such further details as he possessed, which I offered to lay before our Society. Senhor Ribeiro complied with my request most obligingly, and sent me also a rich collection of organic remains illustrative of his notes. To avoid the repetitions inevitable in correspondence, I have condensed the substance of his letters into a connected memoir, to which I have added lists and descriptions of part of the Organic Remains, and to which Mr. Bunbury has kindly added an account of the Fossil Plants, Mr. Salter an account of the Trilobites, and Mr. Jones of the Entomostraca. Senhor Ribeiro had before him my paper on the Secondary Rocks of Portugal (Journ. Geol. Soc. vol. vi. p. 135) and has carefully filled up several gaps left in it, but the principal part of his paper relates to a district which I did not reach.—D. S.

† I referred the Limestone of Mealhada to the Lias on the evidence of an abundance of *Belemnites paxillosus*, *loc. cit.* p. 163. From Casal Combro, near Mealhada, Senhor Ribeiro has sent me *Belemnites clavatus*, Blainv., a Lias species, and *Lucina lirata*, Phillips, of the Inferior Oolite and Lias.—D. S.

Fig. 1. *Geological Map of the Serra de Bussaco and the neighbouring district, Portugal.*



There seem therefore to have been great changes in animal life in the period between the Red Sandstone, and the Jurassic or Liassic Limestone; but while it may be doubtful whether these intermediate beds should be referred to the Lower Lias, or to the upper part of the Red Sandstone, they strengthen the probability that the Red Sandstone below them must be referred to a period altogether distinct from that of the Lias.

New Red Sandstone? or Grès Bigarré?—The Red Sandstone which underlies and fringes the cretaceous and jurassic district of Beira* has been traced for twelve or fourteen leagues from the banks of the Vouga, by Serdaõ and Coimbra, to the neighbourhood of Thomar; and although it is sometimes concealed by more modern sands and sandstones, it has been recognised as one formation. Its mineral characters vary locally, but are in general the same, and resemble those of the *Grès Bigarré* of the French; and although no organic remains have been found in it†, the position it occupies places this classification of it out of doubt.

The Red Sandstone of Beira may be divided for convenience into two stages; an upper division less developed, in which light colours predominate; and a lower division, truly red, more extended, and of greater thickness.

The upper division consists of a more or less coarse sandstone of a light green, white, or ferruginous yellow colour, with patches of green and red, in beds one or two metres thick, separated by thin beds of fine incoherent sandstone of the same colours: it contains silicates of iron, magnesia, &c., small quartzose fragments, and incoherent crystals and fragments of flesh-coloured felspar in an argillo-siliceous cement: the stratification is often irregular, and it does not afford a good building stone: it may be studied at Eiras and Brasfemias, three miles N.N.E. of Coimbra, at St. Jozé de Marianos, and the back of the Botanic Garden at Coimbra, on the heights of the Campo da Ceira, two and a half miles S. of Coimbra, and at Podentes, ten miles S.S.E. of Coimbra.

The lower division, or Red Sandstone properly so called, is more variable in character, but a brick-red colour always predominates, especially in the middle and lower portions. At Goza, Taipa, and Eiral, on the left bank of the Mondego, it is at top a coarse sandstone of a light purple colour, in thin beds, separated by layers of white shale; the above passes into a finer brick-red sandstone with some mica and a little hematite; the red layers alternate with others of green micaceous sandstone, but the whole is so coherent that it may be cut into large blocks, and is extensively used for building-stone; this part of the series cannot be less than 50 metres thick: at Villa Nova de Monsares and Moita, eight miles S. of the points above mentioned, this sandstone is quarried for ornamental buildings; below it is coarser and passes into a conglomerate. At Moita the sandstone is psammitic, carbonaceous, and schistose.

* Journal of the Geol. Soc. vol. vi. p. 160, 161, and p. 165, and Map, p. 136.

† In a subsequent letter Senhor Ribeiro mentions that in the Red Sandstone have been found Calamites of different species from those in the Carboniferous beds below it.

Figs. 2 and 3.—*Sections across the Serra de Bussaco.*

Fig. 2.

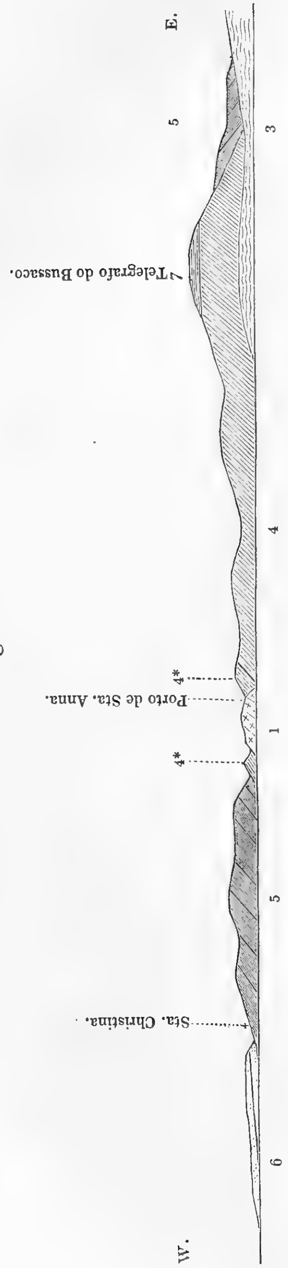
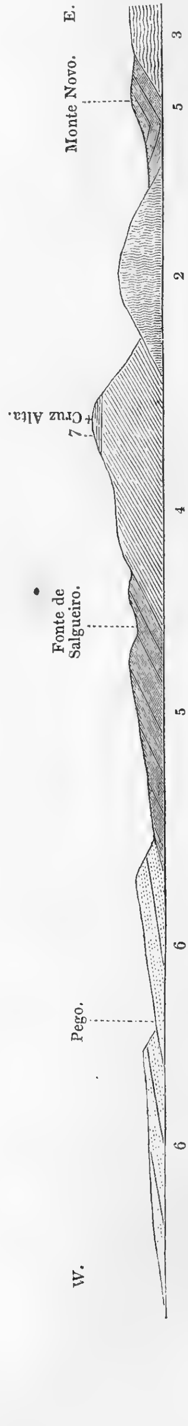


Fig. 3.



1. Diorite.
2. Mica-schist.
3. Clay-slate, without fossils.
4., Silurian rocks.
4*. Altered Silurian rocks.
5. Coal formation.
6. New? Red Sandstone.
7. Sub-cretaceous rocks.

At Luzo and Pego de Seixo, on the west flank of the Serra de Bussaco, the sandstone is coarse and incoherent, of a deep red colour; at Luzo it passes downwards into a very coarse conglomerate which rests on crystalline schists: at Pego de Seixo the beds covering the carbonaceous deposits are a fine purple micaceous sandstone. Finally, at Campo da Ceira it is at the top a hard conglomerate passing down into a green or yellow sandstone, and then into an incoherent conglomerate resting on mica schist: at this spot the total thickness of the two divisions is above 100 metres. The usual dip of the beds is to some point between W. and S. at about 10°, and occasionally as high as 18°; the strike varies from N. to N. 30° W. Where these sandstones rest on the Carboniferous series there is the strongest contrast between the mineral characters of the two rocks and a want of conformability between them, the red sandstone dipping W. only 10°, and the carboniferous beds dipping 20° in the same direction. This want of conformity of the red sandstone with the beds below it, and its separation in respect to organic remains from the Lias above it (*antè*, p. 137), its variegated colours, and its analogy in mineral characters, have led to classifying it with the Grès Bigarré of France.

Carboniferous Formation.—An extensive series of beds of conglomerate, sandstone, clay, and psammite, in all about 400 metres in thickness, and containing an abundance of vegetable remains, extends about two leagues northward and two leagues southward from the north end of the Serra de Bussaco. The prevailing rock is a puddingstone consisting in general of quartz pebbles in a cement of white, yellow or red siliceous sandstones; these pass in places into a coarse, yellow micaceous or carbonaceous sandstone: occasionally, instead of the puddingstone, there is in the lower part of the deposits a breccia of angular fragments of the older argillaceous and micaceous schists of the neighbourhood set in sandstone or in ferruginous clay: this breccia passes into a coarse sandstone with vegetable impressions: the puddingstone also contains petrified stems and sometimes small patches of coal.

The sandstones which alternate with the puddingstones vary in colour and character, and contain small fragments of coal and various vegetable remains; some of the beds resemble those of the basin of anthracite of San Pedro de Cova*; there are also alternating beds of hardened clay or marl. In the middle and lower parts of the formation occur argillaceous beds of various colours and characters, containing geodes of red oxide of iron and well-preserved vegetable impressions in abundance. These are well seen at Fonte do Salgueiro, near the grounds of the Convent of Bussaco.

Between the beds of conglomerate are schistose sandstones interstratified with carbonaceous shale like that which overlies the coal in the coal-fields of England and France, and between these are thin beds of coal varying from ½ inch to 3 inches thick, which burns to a good coke. Both the sandstones and shales contain vegetable impressions†; but the *Asterophyllites* and *Sphenopteris* occur together

* See Journal of the Geol. Soc. vol. v. p. 147.

† Mr. Bunbury's report in the Appendix contains a list of all the Plants sent over by Senhor Ribeiro which were in a condition to be determined.

in certain beds, and *Pecopteris* abounds in others: only one specimen of *Sigillaria* has been met with.

Only one fragment of a *Pecten* has been found in a yellow clay belonging to the beds just described; and they contain no limestone.

The carboniferous beds usually strike N. and S. and dip W. from 30° to 35°, with the least dip in the upper beds; but there are spots where the strike is from N. 26° E. to S. 26° W., and between Villa de Monsarres and Algeris the dip is between 40° and 70° to the E.; but these are local accidents. For three-quarters of a league, between Fonte do Salgueiro and Passo, the carboniferous beds rest unconformably on the fossiliferous Silurian rocks; but to the north and south of those places they overlie chloritic and micaceous schists or old unfossiliferous clay-slates. The chloritic and micaceous schists, between Villa Nova de Monsarres and the Convent of Bussaco, have been elevated subsequently to the deposition of the carboniferous beds, which are disturbed and broken through by the schists; but the red sandstone does not participate in the effect of this movement.

For one league from Linhó de Matta near Larcaõ, to the Fonte do Salgueiro, and also from Villa Nova de Monsarres to the parallel of Junqueira, the carboniferous beds are covered unconformably by red sandstone; in other places they lie in isolated patches on the schistose rocks.

The principal materials of the carboniferous beds are from the debris of granite and similar rocks.

In referring this series to the Coal-formation, it is rather to be compared to that formation in France and England than to the marine Coal-formation of the Asturias. As it is partly concealed by the overlying new red sandstone and subcretaceous sands on the west, and only shows a zone varying from 200 to 800 metres in width of its lower or eastern portion, there may be a greater thickness of the formation concealed to the westward under those overlying formations, in which valuable beds of coal may still be found*.

SILURIAN FORMATIONS.—The Silurian rocks rise from below the carboniferous conglomerates above described, from Passo to the Fonte do Salgueiro, with a general direction of N.W. to S.E., and form the principal part of the Serra de Bussaco; they begin at the northern extremity of that ridge and extend towards the south for five or six leagues, crossing the river Mondego at Pena Cova; they cover a breadth varying from two to three miles, and have a thickness of more than 2500 metres. These beds admit of a division into three principal groups, of which the two lower divisions belong to the Lower Silurian series, and the upper may perhaps be of the age of the Wenlock or lower portion of the Upper Silurian beds of England.

Lowest Division (*Lower Silurian*).—This, which forms the principal part of the formation and occupies the eastern half of the Silurian district, is composed of quartzites, micaceous sandstones, white, yel-

* Senhor Ribeiro's arguments in favour of finding Coal below the Red Sandstone being of a very theoretical character and of local interest, they have been abridged very much in the text.—D. S.

lowish, and black schists, semi-crystalline limestones, and carbonaceous schists. It contains an abundance of Trilobites and shells, which are most plentiful in a very dark greywacke or micaceous schistose sandstone, with well-marked bedding, which occurs in the middle of the formation. The *Trinuclei* are only found in this rock. *Orthis Berthoisi* has been found at Portela de Loredo in the schists with *Trinucleus, Phacops,* &c. The *Asaphi, Calymenes,* and *Illæni* are frequent in the beds which rest on the quartzite, and are accompanied by several species of *Orthis**.

Middle Division of the Silurian Formation (*Lower Silurian*).—An ochreous argillaceous rock of metamorphic character is found resting on the beds just described in several localities along the middle of the Silurian district on a line of N. 35° W. to S. 35° E., always accompanied by greenstone or diorite. In some few localities it contains hollow impressions of *Orthis, Leptæna,* &c., mixed with a great abundance of small branching corals. The rock is hard and yellow; it splits up into prisms, and the bedding can only be distinguished by the layers of hollow impressions of the organic remains. From its peculiar mineral character it might be called Argilolite; in some places it seems to pass insensibly into the diorite with which it is associated. The irregular manner in which these small patches of ochreous rock occur would leave it difficult to assign its true geological position but for the assistance of its organic contents, which clearly refer it to the Lower Silurian epoch; and it will be seen by the list of species that several are common to this and the lowest division of the Silurian formations just described.

The diorite occurs at intervals for about five leagues in several localities, which are marked on the map, following a line of about N. 35° W. to S. 35° E., disturbing the Silurian rocks which it breaks

* Organic Remains of the lower division of the Lower Silurian Rocks:—

Illænus giganteus, *Burm.* pl. 3. f. 10.
I. Lusitanicus, Sharpe, Journ. Geol. Soc. v. t. 6. f. 1.
I. Desmaresti, Rouault, Bull. Soc. Géol. Fr. 2 ser. vol. vi. t. 2. f. 2.
Phacops Dujardini, *Rouault,* Bull. Soc. Géol. Fr. iv. t. 3. f. 5.
—— proævus, *Emmerich, Burm.* t. 4. f. 3. *P. socialis,* Barrande.
Phacoparia Zippei, *Boek.*
Calymene Tristani, *Brong.*
—— Arago, *Rouault,* Bull. Soc. Géol. Fr. vi. t. 2. f. 3.
Trinucleus Pongerardi, *Rouault,* Bull. Soc. G. Fr. 2 ser. t. f.
Ogygia glabrata, *Salter,* n. s.
Beyrichia Bussacensis, *Jones,* n. s.
—— simplex, *Jones,* n. s.
Redonia Duvaliana, *Rouault.*
—— Deshayesiana, *Rouault.*
Nucula Costæ, n. s.
—— Ciæ, n. s.
Nucula Ribeiro, n. s.
—— Ezquerræ, n. s.
—— Eschwegii, n. s.
—— Maestri, n. s.
—— Beirensis, n. s.
—— Bussacensis, n. s.
Leda Escosuræ, n. s.
Dolabra? Lusitanica, n. s.
Cypricardia Beirensis, n. s.
Modiolopsis elegantulus, n. s.
Orthis Ribeiro, n. s.
—— Bussacensis, n. s.
—— fissicosta? *Hall,* t. 32. f. 7.
—— basalis, *Dalm.*
—— testudinaria, *Dalm.*
—— parva, *Pander.*
Pleurotomaria Bussacensis, n. s.
Ribeiria pholadiformis, n. s.

Bellerophon trilobatus, Sil. Syst.
—— carinatus, Sil. Syst.
Theca Beirensis, n. s.

through; but it does not disturb the carboniferous beds which must be posterior to its eruption*.

Upper Division of the Silurian Formation (Upper Silurian).—This consists of beds of light blue shale and argillaceous schists containing none of the species found in the beds below, but characterized by *Cardiola interrupta,* and some other bivalves, *Orthocerata, Graptolites,* &c., all flattened and distorted. These beds extend along the western edge of the Silurian district from Ponte de Matta to Sazes, and are seen to pass below the carboniferous beds between Passo and Portela de Loredo. We may conclude from their organic remains, that the beds belong to the age of the Wenlock formation of England†.

San Pedro de Cova near Vallongo.—An examination of the beds of that locality confirms the view taken by Mr. Sharpe‡, that the Carboniferous series, there worked for coal, is at the base of the Silurian system, and that the position of the Coal below the Silurian slates containing *Trilobites, Orthis,* &c., cannot be explained by a supposed inversion of the whole series of beds.

Argillaceous and Crystalline Schists.—There are two schistose formations in the neighbourhood of Bussaco, below the Silurian series. The upper of these, which may be called *Cambrian,* is an extensive series of unfossiliferous beds consisting principally of argillaceous schists with some grits; their position is marked on the map forming the eastern boundary of the fossiliferous region described in this memoir, and also partially bounding on the west the Silurian ridge of Bussaco. To the same series may probably be referred the schists of Estorreja, Ovar, &c.§, and the lowest beds seen at San Pedro de Cova.

Besides the above there are two small districts of mica schist and chloritic schist which are shown on the map and sections; one between the northern end of the Serra de Bussaco and Villa Nova de Monsarres; the other a little west of that Serra, near Botao.

On the left bank of the Douro below Jeramunde, rising from the

* Organic Remains of the upper division of the Lower Silurian beds:—

Phacops Dujardini, *Rouault,* Bull. Soc. Géol. Fr. iv. t. 3. f. 5.
Dithyrocaris ? longicauda, n. s.
Orthis exornata, n. s.
—— Bussacensis, n. s.
—— Mundæ, n. s.
—— testudinaria, *Dalm.*
—— Berthoisi, *Rouault,* Bull. Soc. Géol. Fr. vi. t. 2. f. 4.
—— parva, *Pander.*
Porambonites Ribeiro, n. s.
Porambonites lima, n. s.
Leptæna Beirensis, n. s.
—— ignava, n. s.
—— deltoidea, *Conrad,* sp., *Hall,* Pal. N. York, t. 31 A. f. 3.
Pleurotomaria Bussacensis, n. s.
Favosites fibrosa, *Goldf.*
Synocladia Lusitanica, n. s.
—— hypnoides, n. s.
Disteichia reticulata, n. s.
Retepora, 1 or 2 species.

† Organic Remains of the upper division of Silurian Rocks:—

Graptolithus Ludensis, Sil. Syst. t. 26. f. 1.
Creseis, 1 species.
Orthoceras, 4 species.
Cardiola interrupta, Sil. Syst. t. 8. f. 5.
Cardium striatum? Sil. Syst. t. 6. f. 2.

‡ See Journ. of Geol. Soc. vol. v. p. 145–148.

§ See Journ. of Geol. Soc. vol. v. pp. 149 & 150.

river towards the Quinta da Lomba at Braziela, about forty metres above the river, the lowest system (Cambrian?) may be observed, consisting of thin, regularly stratified beds of sandstone which splits up into prisms, alternating with schists: above these are beds of coarse conglomerates, containing prismatical fragments of 4 inches to 1 foot across, *evidently derived from the beds below*, angular fragments of quartz, mica schist and chloritic schist mixed with rounded pebbles, in a red or yellow argillaceous cement, with veins of carbonaceous clay; above these are conglomerates and sandstone, beds of coal, &c., the whole dipping east, and above these last are the Trilobite schists dipping conformably to the east, in which *Phacops longicaudatus* has been found in addition to those named by Mr. Sharpe. The existence in the conglomerates of fragments of the rocks below them proves that there has been no inversion of the beds*.

Extension of Subcretaceous Beds to the Eastward.—On some high spots of the Serra de Bussaco are beds of argillaceous sandstone, either white or spotted with red or yellow, alternating with soft ferruginous clay: at the ridge of the Serra the clays are indurated and the sandstones changed to quartzite. These beds rest on the Silurian schists and quartzites, from which they are very distinct. Towards Portela da Venda Nova they cover all the Silurian formation, except a patch at Venda Nova de Poyares, and they extend to the south, the east, the west, and north-west, covering the valleys of Louzaã, Poyares, and Mortagua, and flanking the Serras of Louzaã, Arganil, Felgueira, Caramulo, &c., but pierced through in many places by hills of clay-slate (Cambrian?). A similar deposit forms extensive plains on the eastern side of Beira, as at Sarzedos, Val de Pennamacor, and Idanha Nova, and extending beyond the Elja and the Tagus into Spain. On the north and west of the Serra de Bussaco these sandstones and clays descend below the Portaria of the Convent and cover the red sandstones classed by Mr. Sharpe as subcretaceous. From whence it appears that the subcretaceous sea covered the greater part of the country between the Tagus and the Douro, both to the east and west of the Serra de Estrella. On the Map, fig. 1, this formation is only laid down near Portela da Venda Nova, but it is shown in the sections, figs. 2 & 3.

Appendix, *containing Descriptions of the* Organic Remains.—Appendix A.—*Report on the* Fossil Plants *of the* Carboniferous Formation. By Charles F. J. Bunbury, Esq., For. Sec. G.S.

1. Neuropteris cordata.

2. Odontopteris Brardii.

The same form as that which occurs in the Anthracite formation of the Alps; somewhat smaller than Brongniart's figure, and with

* A corrected list of the Trilobites brought from Vallongo has been drawn up by Mr. Salter and is given in the Appendix.

leaflets less pointed. This fern is characteristic of the coal-fields of central France (St. Etienne and Terrasson), and likewise of the Alpine anthracite: not found in England.

3. Odontopteris obtusa.

The variations of form observable in the different Portuguese specimens of this plant, as in those from the anthracite of Savoy, strengthen my belief that the *O. Brardii* and *O. obtusa* of Brongniart are only the extreme forms of one variable species. Prof. Heer concurs in this opinion. See Quart. Journ. Geol. Soc. vol. vii. Part 2. (Transl.) p. 99.

4. Pecopteris Cyathea.

A very general and characteristic plant of the coal-measures, but found likewise in the anthracites of Savoy.

5. P. Cyathea var.?

Remarkable for the combination of long and narrow leaflets with *simple* side veins. Agrees with Brongniart's fig. 4. pl. 101, in the form of the leaflets, but not in the veins. Some might perhaps consider it a distinct species, but I think there are scarcely sufficient grounds for this.

6. P. arborescens.

A well-characterized specimen. The species occurs in the coal formation near Bath, in several places in France, Germany, and in Maryland, U.S., also in the anthracite of Savoy.

7. Pecopteris arguta.

Found in the coal formation at St. Etienne and Ronchamp in France, and in Rhode Island, U.S., according to Brongniart; not in England. The Portuguese specimens have larger leaflets than those figured by Brongniart.

8. Pecopteris ——.

Comes nearest to *P. gigantea*, Ad. Br., and very likely belongs to that species, but the specimens are not sufficient for positive determination.

9. P. longifolia, Ad. Br. *Diplazites longifolius*, Goepp.

Found in the coal formation at Saarbrück, at Wettin in Saxony, and in Nova Scotia; not in England, as far as I know.

10. Pecopteris oreopteridis?

Seems to agree pretty well with figs. 2 and 3 of Brongniart's pl. 105. His plant occurs in the coal formation in England (Shropshire, according to Morris), France, Saxony, Silesia, and Bohemia.

11. Pecopteris leptophylla, nov. sp. Plate VII. fig. 11.

From Val de Candozo. This is certainly a very distinct species from any that I can find described, though unfortunately the speci-

mens are not in a sufficiently perfect state to allow of a complete description. In the form and size of the leaflets it most resembles the *P. denticulata* and *P. insignis* of the Yorkshire oolite, but its venation is widely different. The texture appears very thin and delicate, from which circumstance I have derived its name. The frond was evidently at least twice pinnated; the leaflets rather closely set, very oblique to the rhachis, and somewhat curved forward, tapering gradually from a broad base to a sharp point, deeply and sharply serrated, and indeed somewhat cut (inciso-serrate); the first segment (next the base) on the upper edge of each leaflet conspicuously larger than the rest, and forming almost a lobe. The lower leaflets of each pinna are as much as $\frac{3}{4}$ inch long, but they diminish rapidly towards the ends of the several pinnæ. Midrib of each leaflet strongly marked; side veins, which terminate in the serratures, remarkably wavy or zigzag, each pinnated with several alternate branches or veinlets, which go off from it at a very acute angle. The venation thus resembles that of Goeppert's *Diplazites* (*Pecopt. longifolia* and *emarginata*), but the form of the leaflets and general *habit* of the plant are widely different.

This species should probably be placed in Brongniart's section *Unitæ*. Its technical character may run thus:—

"Fronde tenerâ bipinnatâ: pinnulis subcontiguis elongato-triangularibus acuminatis subincurvis inciso-serratis, basi sublobatis; venis obliquis flexuosis pinnatis: venulis subparallelis."

12. Sphenophyllum Schlotheimii.

Found in the coal formation of Somersetshire, Saxony, Silesia, and Nova Scotia.

13. Annularia longifolia, Brong. *Asterophyllites equisetiformis*, Lindl. and Hutt.

In the coal formation: Monmouthshire, Saxony, Silesia, and Nova Scotia.

14. Walchia.

This appears to me to be the same with a *Walchia* which M. Adolphe Brongniart showed me, from the slates of Lodève near Montpellier; but as I have no specimens within my reach for comparison, and do not know where any of his *Walchiæ* are figured or described, I cannot identify it. The slates of Lodève are supposed to be *Permian*, but have several fossil plants in common with the coal formation.

Of the fourteen species or varieties here enumerated, all that can be identified with plants previously described, belong to the true coal formation, with the exception perhaps of the *Walchia*, which may be Permian. Four out of the fourteen occur likewise in the anthracite formation of the Alps. Only six out of the fourteen are recorded as British; for the *Odontopteris obtusa* of Lindley and Hutton is generally considered as different from the plant originally so called. The abundance of *Odontopteris* and of *Pecopteris Cyathea*, and the occurrence of *Pecopteris arguta* and *P. oreo-*

pteridis, give the flora of this coal-field a certain resemblance to that of central France. The absence of indications of *Lepidodendron*, *Sigillaria*, and *Calamites* (if it be not merely accidental), is a very remarkable peculiarity.

Appendix B.—*Description of the New Species of* Zoophyta *and* Mollusca. By Daniel Sharpe, Esq., F.R.S., G.S.

Disteichia*, Sharpe.

Polyparium frondosum, reticulatum, bi-laminosum: laminæ celluliferæ, tubulis clausis, transversis conjunctæ: cellulæ tubulosæ externè dehiscentes.

Coral consisting of reticulated fronds, formed of two parallel layers of cells, connected by numerous closed transverse tubes: cells tubular, arranged longitudinally side by side, and opening outwards obliquely at their upper extremity.

These corals differ from *Eschara* and *Flustra* in the more tubular form of their cells, and in having the layers of cells separated into two parallel walls, which are only connected by numerous transverse tubes. They appear to have contained very little calcareous matter.

Disteichia reticulata, n. s. Pl. VII. fig. 8.

D. reticulata; ramis planis, interstitiis subæqualibus, anastomosantibus: ramis junioribus longitudinaliter striatis, celluliferis; adultis, cellulis obtectis, tubis transversis prominentibus.

Reticulated with branches nearly similar throughout, and equal in breadth to the meshes between them; branches covered when young with longitudinal striæ showing the forms of the tubular cells; when old the striæ are obliterated, the cells cannot be distinguished, and the blunt closed ends of the transverse tubes project beyond the wall of the coral producing a finely mammillated surface. Transverse tubes larger than the polyp-cells.

The general form of the coral has not been seen, nor can the shape of the mouths of the cells be distinguished.

The species seems to have reached a large size, as one of the fragments examined is more than 2 inches long; the branches vary from $\frac{1}{8}$th to $\frac{1}{4}$th of an inch in breadth; at the lower part the walls are nearly $\frac{1}{20}$th of an inch apart; at the upper part they are less than half that distance from each other. The transverse tubes are very numerous.

Found in the upper division of the Lower Silurian formation at Sazes and the Porto de Santa Anna, in the Serra de Bussaco.

Plate VII. fig. 8. *a*. A specimen of the natural size.

b. Magnified portion of a young branch, with the surface partially broken off, disclosing the broken ends of the transverse tubes.

* *Disteichia*, having two walls.

c. Magnified portion of another and older specimen, in which the projecting ends of the transverse tubes entirely conceal the polyp-cells.

d. Magnified view of a transverse section.

Synocladia Lusitanica, n. s. Pl. VII. fig. 9.

S. ramosa, ramis bifurcatis, coalescentibusque irregulariter reticulata: cellulis quadri-serialibus, quarum bases ordinum duorum superficiem ramorum externam occupant.

Coral consisting of branches of nearly uniform thickness, which divide and reunite irregularly, forming a very loose network, with long, narrow, unequal meshes: the branches are covered on one side with the openings of the cells, which are usually arranged in four rows, and on the other side they display the closed portions of two of the rows of cells placed alternately. The general form of the coral has not been seen.

Breadth of the branches about $\frac{1}{20}$th of an inch.

This elegant zoophyte and the species next to be described differ from the typical species of Mr. King's genus *Synocladia* in having the forms of two rows of the cells distinctly shown on the reverse of the branches, and also in having the transverse nearly equal to the main branches; but until they are better known they may most fitly be classed in that genus, which is distinguished from its nearest ally, *Fenestella*, by having cells on the cross branches.

Found in the upper division of the Lower Silurian formation at the Porto de Santa Anna, in the Serra de Bussaco.

Plate VII. fig. 9. *a.* Portion of the coral of the natural size.

b. Outer side of a branch magnified.

c. Impression of the inner side of a branch magnified.

Synocladia hypnoides, n. s. Pl. VII. fig. 10.

S. ramosa, ramis bifurcatis coalescentibusque laxè reticulata: cellulis biserialibus, lineâ depressâ utrinque divisis.

Coral consisting of an irregular network of branches which divide and reunite without any order, and which are all formed of two rows of cells: on one side of the branches are seen the openings of the cells separated by a deep, longitudinal depression along the branch; on the other side the outline of each cell is marked by a depressed line, also continued down the middle of the branch.

The general form of the coral has not been seen.

Breadth of the branches about $\frac{1}{30}$th of an inch.

This species is distinguished at once from the preceding by being furnished with only two rows of cells, and also by a more irregular growth; its general habit coupled with the depressed line down each side of the branches give it a strong resemblance to a moss.

Found in the upper division of the Lower Silurian formation at the Porto de Santa Anna, in the Serra de Bussaco.

Plate VII. fig. 10. *a.* Portion of the coral of the natural size.

b. Outer side of a branch magnified.

c. Impression of the inner side of a branch magnified.

Redonia, M. Rouault, Bull. Soc. Géol. Fr. 2 Ser. vol. viii. p. 362.

The following generic character adds some particulars to the description of this curious genus, originally given by M. Rouault:—

Shell equivalve, very inequilateral, with incurved beaks; muscular impressions two, the anterior one bounded by a strong plate; hinge with three? strong teeth on the anterior side of the umbo on each valve, and two long thin teeth on the posterior side nearly parallel to the edge of the shell.

Redonia Deshayesiana, Rouault, Bull. Soc. Géol. Fr. 2 Ser. vol. viii. p. 364. Pl. IX. fig. 1.

R. testâ ovatâ, anticè obtusâ, lunulâ exiguâ depressâ, posticè attenuatâ; sulco mediano longitudinali; lineis concentricis inæqualibus.

Shell ovate, anteriorly blunt, with a small lunette produced posteriorly; with a broad, slightly marked longitudinal depression extending transversely from near the umbo to the margin; concentric lines of growth numerous and unequal.

In the internal cast the umbos are produced into a point and incurved; the anterior muscular impression is separated by a deep hollow (left by the internal plate) from the umbo; the posterior muscular impression is very near the posterior margin.

Length $\frac{5}{8}$ inch, breadth 1 inch.

Common in the Lower Silurian beds of Riba de Baixo, Valeiro do Arruido, and other localities in the Serra de Bussaco.

It has been found by M. Rouault in the Lower Silurian slates of Vitré, Gahard, and Monteuf of Brittany.

Plate IX. fig. 1. *a*. Exterior. *b*. Internal cast. *c*. Hinge-teeth.

Redonia Duvaliana, Rouault, Bull. Soc. Géol. Fr. 2 Ser. vol. viii. p. 365. Pl. IX. fig. 2.

R. testâ transversim ovatâ, anticè gibbosâ; rugis concentricis inæqualibus.

Shell transversely ovate, anteriorly gibbose, marked with numerous unequal concentric ridges: posterior muscular impression near the middle of the dorsal margin.

Length $\frac{5}{8}$, breadth $\frac{7}{8}$ of an inch.

Found in the lower division of the Lower Silurian formation at Riba de Baixo, in the Serra de Bussaco. M. Rouault's specimens are from the Lower Silurian slates of Vitré, Brittany.

This species is readily distinguished from *R. Deshayesiana* by the want of a lunette and being less inequilateral; it appears also to be less abundant than that species. The position of the posterior muscle also helps us to distinguish the two species.

Plate IX. fig. 2. *a*. Exterior. *b*. Cast of interior.

Nucula Costæ, n. s. Pl. IX. fig. 4.

N. testâ triangulari-ovatâ; lineis crebris concentricis; dentibus cardinalibus 25–30 inæqualibus.

Shell ovato-triangular, with four or five deeply impressed lines of

growth, between which the surface is covered with closely set equal concentric lines: muscular impressions equally strong: cardinal teeth unequal, about twelve anterior and six posterior meeting at the umbo; the largest in the middle of each series.

Length 0·3, breadth 0·4 of an inch.

Abundant in the lower division of the Lower Silurian formation of the Serra de Bussaco.

Named after Dr. F. A. Pereira Costa, of Lisbon.

PLATE IX. fig. 4. *a.* Exterior. *b.* Interior.

NUCULA CIÆ, n. s. PL. IX. fig. 5.

N. testâ transversim ovatâ, concentricè lineatâ; impressione musculari posticâ maximâ; dentibus cardinis anticis 9 parvis, posticis 10 majoribus inæqualibus.

Shell transversely ovate, covered with fine concentric lines: anterior muscular impression moderate, posterior very large: hinge-teeth in two sets separated by a vacant space at the umbo; anterior ten, small; posterior nine or ten, long and unequal.

Length 0·4, breadth 0·6 of an inch.

Found in the lower division of the Lower Silurian formation of the Serra de Bussaco.

Named in honour of Don P. Cia, of Madrid.

PLATE IX. fig. 5. *a.* Exterior. *b.* Interior. *c.* Hinge-teeth.

NUCULA RIBEIRO, n. s. PL. IX. fig. 6.

N. testâ triangulari-globosâ, concentricè eleganter lineatâ, dentibus cardinalibus 30 inæqualibus continuis.

Shell globose with a depression in front of the beaks; elegantly marked with ten or twelve equidistant strong rings, between every two of which are five or six equal close-set concentric lines; anterior muscular impression large and deep, posterior one faint: hinge-teeth about thirty, continuous, five or six long teeth on the anterior side; about fifteen very small teeth in a curve round the umbo, and about ten of intermediate size on the posterior side.

Length and breadth $\frac{5}{8}$ of an inch.

Found in the lower division of the Lower Silurian formation at the Portela de Loredo, in the Serra de Bussaco, and named after Senhor Carlos Ribeiro.

PLATE IX. fig. 6. *a.* Exterior. *b.* Interior. *c.* Hinge-teeth.

NUCULA EZQUERRÆ, n. s. PL. IX. fig. 7.

N. testâ ovatâ, lineis concentricis inconspicuis; dentibus cardinis subæqualibus, anterioribus 5, posterioribus 15.

Shell ovate, marked with some inconspicuous concentric lines; muscular impressions slight: hinge-teeth about twenty, fifteen posterior, five anterior, separated by a small vacant space on the anterior side of the umbo, those below the umbo small, the rest nearly equal.

Length $\frac{1}{4}$, breadth $\frac{3}{8}$ of an inch.

Found in the lower division of the Lower Silurian formation at the Porto de Louza, in the Serra de Bussaco.

Named in honour of Don J. Ezquerra del Bayo, of Madrid.

Plate IX. fig. 7. *a*. Exterior. *b*. Interior.

Nucula Eschwegii, n. s. Pl. IX. fig. 10.

N. testâ ovatâ, anticè sub umbonibus excavatâ, læviusculâ; dentibus cardinalibus parvis numerosis.

Shell ovate, with a depression in front below the beaks; nearly smooth, with a few inconspicuous lines of growth: hinge-teeth small.

Length $\frac{4}{10}$, breadth $\frac{6}{10}$ of an inch.

Found in the lower division of the Lower Silurian formation in the Serra de Bussaco.

The hinge-teeth have not been clearly seen; they are numerous on the posterior, and few on the anterior side.

I name this species after Baron Eschwege, one of the earliest writers on the geology of Portugal.

Plate IX. fig. 10. *a*. Exterior. *b*. Interior.

Nucula Maestri, n. s. Pl. IX. fig. 9.

N. testâ subrotundâ, subæquilaterali, læviusculâ, lineis concentricis paucis.

Shell slightly angular at the beaks, otherwise nearly round, marked with three or four impressed concentric lines; beaks nearly medial: hinge-teeth small and numerous.

A clumsy, inelegant shell; the teeth have not been well seen.

Diameter $\frac{3}{4}$ of an inch.

Found in the lower division of the Lower Silurian formation at the Portela de Loredo, in the Serra de Bussaco.

Named after Don Amalio Maestre of Madrid.

Plate IX. fig. 9. *a*. Exterior. *b*. Hinge-teeth.

Nucula Beirensis, n. s. Pl. IX. figs. 11 & 12.

N. testâ subglobosâ, umbonibus prominulis, læviusculâ, lineis paucis concentricis: cardine arcuato, dentibus anticis 3 majoribus, posticis 20 subæqualibus: lamellâ interiori musculum anticum limitante.

Shell subglobose with projecting slightly anterior beaks, marked with a few concentric lines: hinge arched, with three strong anterior teeth separated by an interval from about twenty smaller equal posterior teeth: anterior muscular impression deep, and bounded on its inner side by a strong plate.

Diameter $\frac{7}{8}$ of an inch.

Found in the lower division of the Lower Silurian formation at Riba de Baixo, in the Serra de Bussaco.

This species and the following one, *N. Bussacensis*, are distinguished from the usual forms of *Nucula* by having a strong internal plate bounding the anterior muscle on its inner side, similar to the internal plate of *Cucullæa glabra*, &c., and to that of the genus *Redonia*: as in other respects they appear to agree with *Nucula*,

they are left in that genus. Neither in these nor any of the species of *Nucula* described in this paper can we detect the internal ligamental pit; but as all the specimens are mere casts, it is impossible to say that it has not existed in them.

Plate IX. fig. 11. Internal cast.

Fig. 12. Internal cast of another specimen.

Nucula Bussacensis, n. s. Pl. IX. figs. 13 & 14.

N. testâ transversim ovatâ; lineis inconspicuis concentricis: cardine subarcuato, dentibus 4 anticis, 12–15 posticis: lamellâ interiore, musculum anticum limitante.

Shell transversely ovate with a slight anterior depression below the beaks, marked with some faint concentric lines: hinge curved, with four anterior and twelve to fifteen posterior teeth: anterior muscular impression deep, and bounded on its inner side by a strong plate.

Length $\frac{1}{2}$, breadth $\frac{3}{4}$ of an inch.

From the lower division of the Lower Silurian formation of the Serra de Bussaco.

Plate IX. fig. 13. Internal cast.

Fig. 14. *a* & *b*. Exterior and internal cast of another imperfect specimen.

Leda Escosuræ, n. s. Pl. IX. fig. 8.

L. testâ transversim elongatâ, læviusculâ, anticè rotundatâ, posticè rostratâ: umbonibus prominulis: cardine recto, dentibus numerosis, continuis, inæqualibus.

Shell transversely elongated, with projecting beaks: anterior end rounded, posterior produced into a long beak: hinge straight, with a continuous row of very numerous small teeth.

Length $\frac{1}{3}$, breadth $\frac{3}{4}$ of an inch.

Found in the lower division of the Lower Silurian formation at the Portela de Loredo, in the Serra de Bussaco.

In the specimen figured, the end of the posterior side is incomplete.

Named after Don Luis de la Escosura.

Plate IX. fig. 8. *a*. Exterior. *b*. Internal cast.

Dolabra? Lusitanica, n. s. Pl. IX. fig. 3.

D.? testâ transversim ovato-rhomboideâ, concentricè lineatâ, anticè rotundatâ, posticè subangulatâ: cardine recto, dentibus anticis 2 vel 3?, posticâ unicâ, elongatâ, crenulatâ.

Shell transversely ovato-rhomboidal, covered with unequally raised, concentric lines; anterior end broad and rounded, posterior side sloping with an obscure rounded ridge extending from the beak to the posterior extremity. Hinge with two or three? strong anterior teeth and a long posterior plate parallel to the hinge-line, which is crossed by numerous small teeth or crenulations.

Length $\frac{3}{4}$, breadth $\frac{1}{10}$ of an inch.

Common in the lower division of the Lower Silurian formation of the Serra de Bussaco.

This shell is placed in Professor M'Coy's genus *Dolabra* on account of the crenulated plate or tooth on the posterior side of the hinge and distinct anterior teeth: these characters connect it also with *Redonia*, from which it differs in its more rhomboidal form, and in wanting entirely the internal plate of that genus, and in the crenulation of the posterior part of the hinge. The condition of the specimens, which are only casts, does not admit of any certainty on the subject. In external form it resembles *Pullastra lævis*, Sil. Syst.

Plate IX. fig. 3. *a*. Exterior. *b*. Cast of interior.

Cypricardia? Beirensis, n. s. Pl. IX. fig. 16.

C. testâ transversim rhomboideo-ovatâ, sublævi; anticè rotundatâ, ampliore; posticè obliquâ; margine ventrali depresso.

Shell transverse, ovato-rhomboidal, nearly smooth, with a few inconspicuous lines of growth: front slightly depressed; anterior end rounded and wider than the posterior end; with a long tooth or plate parallel to the posterior side of the hinge-line; anterior teeth?

Length $\frac{4}{10}$, breadth $\frac{7}{10}$ of an inch.

From the lower division of the Lower Silurian formation of the Serra de Bussaco.

This much resembles several of our Upper Silurian species, with none of which it can be identified; the condition of the specimen does not allow the anterior tooth to be made out.

Plate IX. fig. 16. *a*. Exterior. *b*. Cast of interior.

Modiolopsis elegantulus, n. s. Pl. IX. fig. 15.

M. testâ obliquè transversâ, concentricè lineatâ; lineâ cardinali rectâ, umbonibus mediis; anticè angustatâ, posticè expansâ, rotundatâ.

Shell oblique, concentrically striated, with slightly projecting beaks placed in the middle of a long, straight hinge-line; anterior end narrow, posterior end widened and rounded.

Length $\frac{1}{4}$, breadth $\frac{1}{2}$ an inch.

From the lower division of the Lower Silurian formation at Valeiro do Arruido, in the Serra de Bussaco.

The single specimen seen of this shell does not show the characters of the hinge; but in form and in the very forward position of the anterior muscle, it agrees with the shells which Mr. Hall has thrown together under the name of *Modiolopsis*; indeed it might pass for a young shell of *M. modiolaris* but for the position of the beaks, which in that shell are more anterior.

Plate IX. fig. 15. *a*. Exterior. *b*. Internal cast.

Orthis Ribeiro, n. s. Pl. VIII. fig. 1.

O. testâ concavo-convexâ, semi-ovali, angulis productis, striis numerosissimis dichotomis radiantibus ornatâ; valvâ dorsali medio convexâ, lateraliter depressâ; valvâ ventrali medio depressâ, lateribus elevatâ; areâ cardinali angustâ, lateraliter productâ.

Shell concavo-convex, semi-oval with produced sides; covered with

very numerous, fine, dichotomising ribs which all radiate from the apex to the margin.

Dorsal valve elevated along the middle, and depressed towards the side margins.

Ventral valve depressed down the middle, and elevated towards the side margins, having thus an undulating surface. Hinge-area narrow, produced at the extremities.

This very elegant *Orthis* differs from all the species yet figured, in combining the outline of a *Spirifer* with produced angles with fine dividing rays all springing from the apex.

The English species most nearly allied to it is the *Spirifer alatus* of the Sil. Syst., which Mr. Morris has properly transferred to the genus *Orthis*.

I have named this species after Senhor Carlos Ribeiro, to whom we owe the information contained in the present paper.

Length $\frac{3}{4}$ of an inch, breadth at the hinge $1\frac{1}{2}$ inch.

Common in the Lower Silurian rocks of the Serra de Mucela, east of Coimbra.

Plate VIII. fig. 1 *a*. Dorsal valve, exterior.

Fig. 1 *b*. Dorsal valve, interior.

Fig. 1 *c*. Ventral valve, exterior.

Fig. 1 *d*. Ventral valve, interior.

Orthis exornata, n. s. Pl. VIII. fig. 2.

O. testâ subrotundâ, plano-convexâ, costatâ; costis 7–8 elevatissimis acutis, bis trichotomis.

Shell plano-convex, with a rounded outline; dorsal valve very convex, ornamented with seven groups of highly elevated sharp ribs; each group consists of a single rib starting from the umbo, and soon dividing into three, of which the middle rib is the largest; each of these ribs divides again into two or three near the margin.

Ventral valve nearly flat, with eight groups of ribs less elevated but similar in character to those of the other valve.

Hinge-line rather less than the greatest width of the shell.

Length and breadth the same, 0·45 inch.

This very elegant little shell is distinguished by its peculiar ribbing from all its fellows; the species which come nearest to it are *O. fissicosta* and *O. plicatella* of Hall, and *O. Actoniæ*, Sil. Syst.

Found in the upper division of the Lower Silurian formation at Sazes and the Porto de Santa Anna, in the Serra de Bussaco.

Plate VIII. fig. 2 *a*. Dorsal valve, exterior.

Fig. 2 *b*. Dorsal valve interior.

Fig. 2 *c*. Ventral valve, exterior.

Fig. 2 *d*. Ventral valve, interior.

Orthis Bussacensis, n. s. Pl. VIII. fig. 3.

O. testâ transversim ovatâ, costatâ; costis numerosis di- vel tri-chotomis, lateralibus confertissimis, mediis rarioribus.

Shell transversely ovate, with both valves slightly convex and similarly ornamented with numerous fine ribs, which subdivide two or

three times before they reach the margin, where they are between 70 and 80 in number: the ribs are more closely crowded together at the sides than on the front of the shell.

Hinge-line nearly of the extreme width of the shell, with its angles slightly rounded off.

Length $\frac{1}{2}$ an inch, breadth $\frac{3}{4}$ of an inch.

Found in both divisions of the Lower Silurian beds in the Serra de Bussaco.

Only one valve is figured, as the impressions of the two valves cannot be distinguished. The character by which the species is most easily recognized is the crowding of the side ribs contrasted with the looser ribbing of the front of the shell.

Orthis Mundæ, n. s. Pl. VIII. fig. 5.

O. testâ truncato-ellipticâ, convexiusculâ, costatâ; costis numerosis rotundatis inæqualibus, lateralibus arcuatis; lineis transversis concentricis creberrimis.

Shell truncato-elliptical, slightly convex, ornamented with numerous narrow rounded unequal ribs all springing from the umbo, increasing in number towards the margin, and crossed by numerous concentric lines; the side ribs are curved: end of the hinge-line slightly rounded off: shell thin, with the ribbing distinctly marked on the interior.

Length $\frac{8}{10}$ths, breadth 1 inch.

From the upper division of the Lower Silurian formation at the Porto de Santa Anna, in the Serra de Bussaco.

Plate VIII. fig. 5 *a*. Dorsal valve, exterior.

Fig. 5 *b*. Dorsal valve, interior.

Orthis Berthoisi, Rouault, Bull. Soc. Géol. Fr. 2 Ser. vol. vi. t. 2. f. 4. Pl. VIII. fig. 4.

O. testâ ovatâ, utrinque convexiusculâ, striatâ; valvâ ventrali majore ad apicem depressiusculâ; striis numerosissimis subæqualibus dichotomis, mediis rectis, lateralibus arcuatis; lineis concentricis raris.

Shell ovate, with a very short hinge-line; dorsal valve slightly convex; ventral valve more convex than the dorsal, with a slight mesial depression, which beginning at the umbo dies out before reaching the middle of the valve; both valves covered with very numerous fine bifurcating ribs, which divide many times before they reach the margin, and are crossed at irregular distances by strong concentric lines; lateral ribs curved.

Length 1 inch; greatest breadth below the middle, $\frac{4}{5}$ of an inch.

Abundant in the upper division of the Lower Silurian formation at the Porto de Santa Anna, in the Serra de Bussaco.

In general form and external markings this shell closely resembles the common Carboniferous species *Orthis Michelini* of Leveillé (*O. filiaria*, Phill.); the only obvious distinction being the slight depression near the umbo of the deeper valve; but the form of muscular impressions of the dorsal valve affords a sufficient distinction.

The specimens figured by M. Rouault are much distorted, and only show the exterior, for which reason the species is re-figured here. It is interesting as a connecting link with the Lower Silurian strata of Brittany, and should teach us caution in assigning an age to unknown strata from the general form of a shell without strict attention to specific differences; as, had this species been found alone, most palæontologists would have referred it to the Carboniferous period.

Plate VIII. fig. 4 *a*. Dorsal valve, exterior.
Fig. 4 *b*. Dorsal valve, interior.
Fig. 4 *c*. Ventral valve, exterior.
Fig. 4 *d*. Ventral valve, interior.

Porambonites, Pander *in part*.

A slightly-inequivalved brachiopod with both valves convex, and with a rounded or ovate outline; hinge-line very short, with a very small area and small triangular opening below the umbo of each valve: two strong dental plates on each valve with their bases parallel and approximate: surface of the shell punctated.

In the second volume of the 'Géologie de la Russie d'Europe,' p. 128, M. de Verneuil has brought together under the section of *Spirifers anormaux, équirostres*, a group of shells which had first been published under the generic name of *Porambonites* by M. Pander, along with some others which belong to different genera. The characters which separate these species from the normal form of *Spirifer* are their oval form, with very short hinge-lines; an area and opening, with a pair of strong dental plates to the hinge of each valve, and the punctated structure of the shell. They are allied to *Spirifer biforatus* in the double area and opening and in their punctated structure; but they differ from that species in their oval form and in having similar dental plates on both valves. In form and internal structure these species approach nearer to *Pentamerus* than to *Spirifer*, but the dental plates differ materially from those of *Pentamerus*, and the punctated structure forms another distinction which must never be overlooked in the classification of the Brachiopoda. I propose, therefore, to place these shells in a separate genus, restoring to them M. Pander's original name of *Porambonites*, as has already been done by Prof. M'Coy. The following species published by M. de Verneuil belong to this genus: *Spirifer reticulatus, S. porambonites, S. æquirostris*: three others, *S. Tcheffkini, S. rectus,* and *S. Panderi,* require farther examination of their internal structure to decide whether they belong to this genus, or are to be classed with *S. biforatus* in some other genus. Professor M'Coy quotes one species of this group from the Upper Tweed; and it is probable that *Atrypa crassa*, Sil. Syst., and *Terebratula Capewellii*, Davidson, will have to be placed in it.

Two new species of the same genus occur in the collection sent by M. Ribeiro from Bussaco, which are distinguished by their large size compared with those previously known, and by having no sinus nor mesial fold.

PORAMBONITES RIBEIRO, n. s. PL. VIII. fig. 7.

P. testâ transversim ellipticâ, subventricosâ, punctatâ, lævi; umbone dorsali subproducto; punctis impressis lineas radiantes concentricasque describentibus.

Shell transversely elliptical, with the dorsal valve somewhat produced at the beak, giving that valve rather a pentagonal outline; both valves moderately and equally convex; smooth; surface everywhere impressed with small punctures visible to the naked eye, which are arranged so as to form lines radiating from the umbo and concentric rings. Interior of each valve furnished with two strong dental plates, the bases of which are near together and parallel, and which extend more than half-way along the length of each valve.

Length $1\frac{1}{4}$ inch; breadth $1\frac{5}{8}$ of an inch.

Found in the upper division of the Lower Silurian rocks at the Porto de Santa Anna, in the Serra de Bussaco.

The collection sent by M. Ribeiro, after whom the species is named, contains several specimens with impressions of the interior and exterior of each valve of this interesting shell: the matrix is so friable that all are imperfect, but enough remains to show its principal characters. It differs from all the Russian species in having no indication of either sinus or mesial fold, in which it agrees with the species next to be described.

PLATE VIII. fig. 7 *a*. Exterior. Fig. 7 *b*. Internal cast of dorsal valve.

Fig. 7 *c*. Internal cast of ventral valve.

Fig. 7 *d*. Portion of surface magnified.

PORAMBONITES LIMA, n. s. PL. VIII. fig. 6.

P. testâ transversim ovatâ, subventricosâ, tubulis minutis exsertis asperâ.

Shell transversely elliptical, convex; surface rough with minute, close-set, projecting tubes; dental plates large.

Breadth $1\frac{3}{4}$ inch.

Found in the upper division of the Lower Silurian formation at the Porto de Santa Anna, in the Serra de Bussaco.

Only one imperfect specimen has been seen, so crushed as not to show the outline complete: the form was probably nearly that of the last species, from which it differs in having the punctures produced into small slightly projecting tubes; the dental plates are similar to those of the last species.

PLATE VIII. fig. 6 *a* & *b*. Internal cast and exterior of one specimen. Fig. 6 *c*. Portion of surface magnified.

LEPTÆNA BEIRENSIS, n. s. PL. VIII. fig. 8.

L. testâ truncato-ellipticâ, convexiusculâ, costatâ, concentricè lineatâ; costis numerosissimis tenuibus, inæqualibus.

Shell truncato-elliptical, very slightly convex, covered with very numerous narrow radiating ribs separated by rounded furrows; the ribs increase in number by the frequent insertion of thinner ribs between the others, and are crossed by numerous closely set concentric lines, besides which there are two strongly-marked lines of growth

at a considerable distance apart. Hinge-line equal to the greatest width of the shell.

Length 1·1, breadth 1·2 inch.

Found in the upper division of the Lower Silurian formation at the Porto de Santa Anna, in the Serra de Bussaco.

This shell closely resembles the next described, *L. ignava,* and perhaps they may prove the opposite valves of one species.

Plate VIII. fig. 8 *a*. Dorsal valve, exterior.

Fig. 8 *b*. Dorsal valve, internal cast.

Leptæna ignava, n. s. Pl. VIII. fig. 9.

L. testâ truncato-ellipticâ, planiusculâ, costatâ, concentricè lineatâ et corrugatâ; costis dichotomis, ad apicem rotundatis, deinde subobsoletis.

Shell truncato-elliptical, very thin and nearly flat, with the hinge-line almost of the greatest width of the shell, ornamented near the umbo with numerous rounded bifurcating ribs crossed by indented lines; farther from the umbo the ribs become fainter and gradually obsolete, while the concentric lines become irregular waving wrinkles.

Length 1 inch, breadth the same.

Found in the upper division of the Lower Silurian beds at the Porto de Santa Anna, in the Serra de Bussaco.

Only one valve of this shell has been seen, and it may perhaps prove to be the ventral valve of the preceding species, *L. Beirensis,* to which it is very nearly allied.

Pleurotomaria Bussacensis, n. s. Pl. IX. fig. 18.

P. testâ læviusculâ, ambulacris sex, junioribus depresso-rotundatis, ultimo subangulari; aperturâ sinu medio profundiusculo.

Shell smooth, with six rounded whorls separated by a deep suture; the upper whorls slightly depressed, the last somewhat angular in the middle; opening with a deep sinus corresponding to the angle on the whorl.

Height 1 inch; greatest diameter 1 inch.

Found in both divisions of the Lower Silurian formation of the Serra de Bussaco.

Ribeiria, Sharpe.

Testa univalvis, elongata, lateraliter compressa; aperturâ elongatâ, angustâ: intus laminâ transversali anteriore et impressione musculari elevatâ elongatâque munita.

Shell univalve, elongated, laterally compressed into the form of a Pholas or Lithodomus; open at both ends and along the pedal margin, with a thick transverse internal plate near the anterior extremity, behind which is a very large corrugated boss for the attachment of a muscle.

This curious shell appears related to the family of *Calyptræidæ,* but it shows no trace of a spiral growth; as far as can be judged from the imperfect specimens seen, it is equilateral, and both the transverse internal plate and the muscular attachment are placed along the middle of the back of the shell; the external form may be described as a Calyptræa pressed together laterally till the sides nearly meet, leaving only a narrow opening for the foot of the animal.

The genus is named after Senhor Carlos Ribeiro.

RIBEIRIA PHOLADIFORMIS, n. s. PL. IX. fig. 17.

R. testâ compressâ, subovatâ, anticè rotundatâ, posticè attenuatâ; lineis concentricis crebris inæqualibus.

Shell subovate, laterally flattened, rounded at the anterior extremity, and somewhat narrowed posteriorly; opening narrow, extending round three sides of the shell; surface covered with sharp unequal concentric lines.

Length 1 inch; depth $\frac{1}{2}$ an inch; thickness $\frac{1}{4}$ of an inch; width of opening $\frac{1}{16}$ of an inch.

From the lower division of the Lower Silurian formation of the Serra de Mucela and the Serra de Bussaco.

PLATE IX. fig. 17 *a*. Exterior.
Fig. 17 *b*. Internal cast, side view.
Fig. 17 *c*. Internal cast, dorsal view.

THECA BEIRENSIS, n. s. PL. IX. fig. 19.

T. testâ depressâ, vaginiformi, lineis transversis inæqualibus ornatâ, anticè subrotundatâ, posticè angulato-sulcatâ, angulis lateralibus rotundatis.

Sheath straight, tapering to a blunt point; marked at irregular intervals with sharp transverse lines of growth, with an angular furrow down the middle of the back; rounded in front; lateral angles rounded off.

Length $1\frac{1}{4}$ inch; greatest breadth $\frac{1}{3}$ inch.

Abundant in the Lower Silurian rocks of Riba de Baixo, in the Serra de Bussaco.

PLATE IX. fig. 19 *a*. Front view. Fig. 19 *b*. Back view.
Fig. 19 *c*. Cast of interior.

DITHYROCARIS? LONGICAUDA, n. s. PL. VII. fig. 3.

D. caudâ elongatâ, trispinosâ, spinâ mediâ longissimâ.

Only the tail of this specimen is preserved, and it is referred to *Dithyrocaris* doubtfully; it is formed of two parts, the upper simple and rounded, the lower formed of three lancet-shaped pieces, of which the middle one is somewhat rounded and twice as long as the lateral plates, which are nearly flat. In the species hitherto figured these three caudal appendages are nearly equal in length.

From the upper division of the Lower Silurian formation at Sazes, in the Serra de Bussaco.

APPENDIX C.—*Notes on the* TRILOBITES.
By J. W. SALTER, Esq., F.G.S.

IN the list of Trilobites at p. 141, several species will be recognized as identical with those from the Lower Silurian rocks of France; and in the case of *Illænus giganteus*, I have ventured to reunite a species found both in Portugal and Spain with the common form which attains such large size in the slates of Angers.

1. *Illænus giganteus*, Burm. (*I. Lusitanicus*, Sharpe, Geol. Journ. vol. v. p. 146). In the proportion of the axis to the sides of the body, and in the position of the fulcrum, as well as the converging axal furrows in the head and tail, the species seem to agree closely; and

the character relied on by Mr. Sharpe for the distinction of *I. Lusitanicus,* namely the shape of the glabella and head, is due to pressure, as the better specimens we now possess show clearly. Pl. VII. fig. 1 shows the smallest of the specimens collected, and appears not to have been altered (as many of the others have been) in form.

Illænus Lusitanicus, therefore, of the former list, vol. v. pp. 146 & 150, pl. 6. fig. 1, is regarded by me as a synonym of *I. giganteus,* Burm., and of *I. Desmaresti* of M. Rouault.

2. *Placoparia Zippei* (Corda), *Trilobites Zippei* of Boeck (Pl. VII. figs. 2, *a—e*). This agrees in nearly all particulars with the description and figure lately given by M. Corda, Prodrome Tril. Bohême, t. vi. f. 71. In Barrande's figure*, however, which is strictly correct, the front of the head does not extend so far forwards beyond the glabella, and is therefore still more like ours. Both authors figure and describe twelve body rings, and in our specimen there are not more than ten or eleven at most: and the convex lobes of the tail, though exactly alike in form and number, both on the axis and sides, are further apart from each other than in our Trilobite. This last character is due to the Bohemian specimens being internal casts, while ours (2 *a*) shows the external surface. And we take the opportunity of figuring with it (2 *b—d*) a specimen from Vallongo formerly referred (vol. v. p. 146) to *Cheirurus.* The perfect tail, fig. 2 *e*, is also from the latter locality.

Placoparia differs from *Cheirurus* both in general habit and in the reduced size of the front lobe of the glabella, and also in a peculiarity in the cheeks, which somewhat below the minute eyes are deeply grooved across (fig. 2 *a*) so as to cut off a small lobe which lies parallel to the upper margin of the head and opposite the foremost lateral lobe of the glabella. The free cheeks are very small and narrow, and the eyes minute and forward. The axis of the tail has five, while *Cheirurus* has but four rings—the terminal one, however, is very minute.

3. We prefer to give the name *Phacops proævus,* Emmr., to the species which is so abundant in Bohemia, and which is now more generally known as *P. socialis,* Barrande. There is no doubt of the identity of the species.

4. Another *Phacops* occurs with the last at Bussaco which nearly resembles it, but has the head quite pointed in front, and considerably inflated there, while the upper glabella furrows are almost obsolete; the tail that accompanies it has fewer ribs than that of *P. proævus,* and is drawn out into a broader and thicker point. Our specimens are not good enough to figure.

5, 6. *Calymene Tristani* and *C. Arago* occur in very good condition, the latter distinguished easily by the smooth sides to the tail. Both are also found in Spain.

7. *Trinucleus Pongerardi,* Rouault. We have no specimens which show the branched head-spines, all the specimens having simple spines directed straight backwards. But the fringe is inflated † and

* Syst. Sil. de Bohême, pl. 29. f. 30–38.

† In the common British species, *T. concentricus* (*Caractaci,* Sil. Syst.), the upper surface of the fringe is flat, and the lower side angular.

the perforations large and squarish, and the tail also is small, smooth, and with the point a little incurved. In all these particulars it agrees with M. Rouault's species; although in his specimens the branched head-spines were the rule, and the simple ones the exception.

8. *Ogygia? glabrata*, n. s. Pl. VII. fig. 4. We are induced to give a name to this very distinct fragment, as there appears to be no published species to which it can be referred. It is equally likely to belong to the genus *Asaphus*.

Tail an inch and a half wide, semicircular, with the sides very slightly flattened; the axis gently convex, not quite half the width of one of the sides; it extends nearly three-quarters of the length of the tail, and then runs out for a further distance into a conical appendage, which fades into the general depressed surface. The upper part of the axis is marked by three faint rings, the rest smooth; sides with four or five flattened ribs (besides the broad upper articulating margin) separated by narrow sharp radiating furrows, which do not reach much more than half-way to the margin. Surface quite smooth, except a few concentric lines near the margin, and some obscure transverse lines on the middle of the axis.

As Mr. Sharpe gives me full permission to revise his former list of fossils from Vallongo, vol. v. p. 146, I will add that there occur at that locality—

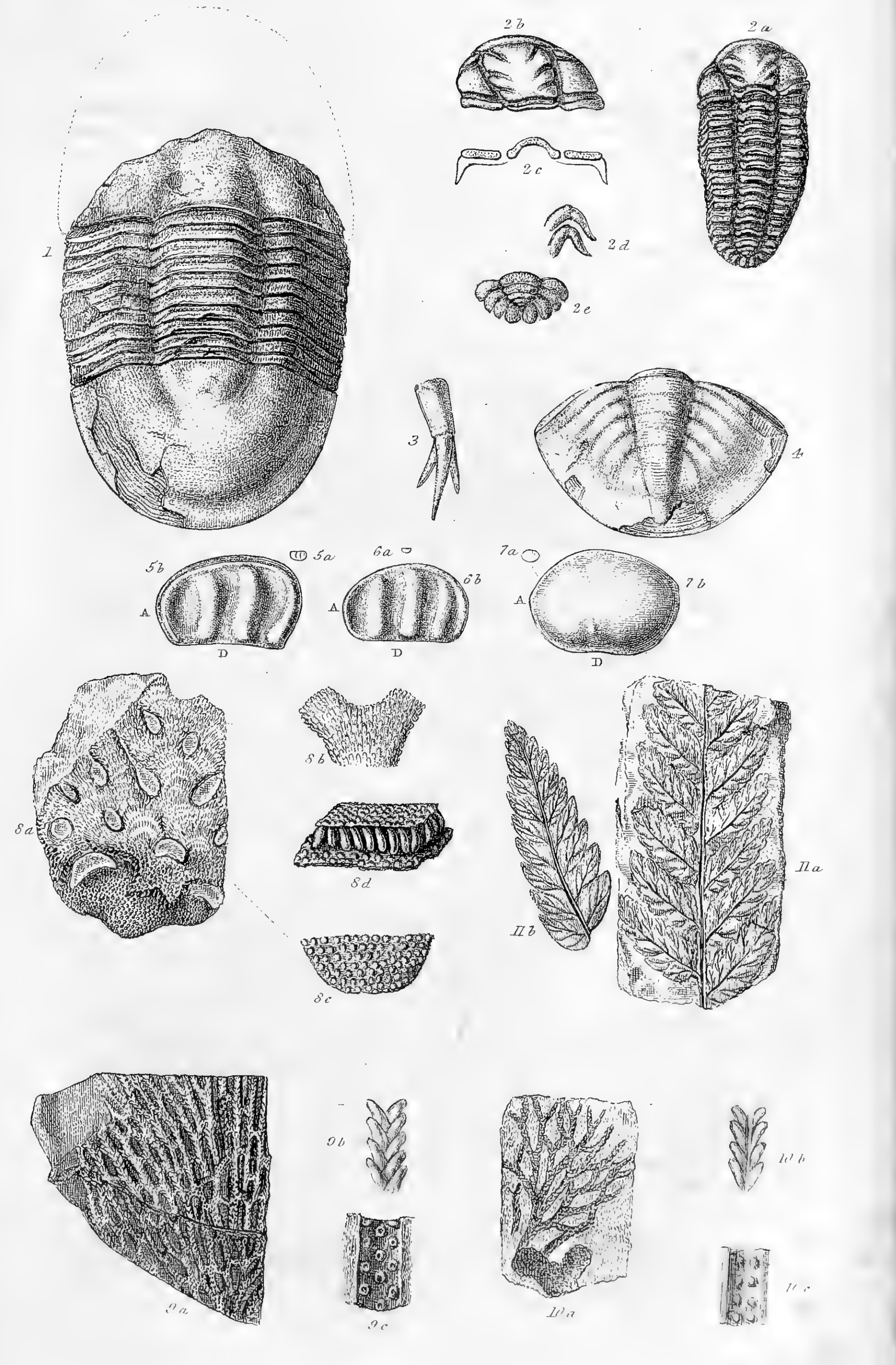
1. *Calymene Tristani*, Brongn.
2. —— *Arago*, Rouault.
3. *Asaphus Guettardi* *, Brongniart?
4. —— *Desmaresti*, Brongn. (*O. Edwardsi*, Rouault).
5. *Asaphus*, a species probably quite new, with extremely wide tail and a short axis (*Isotelus Powisii* of the former list).
6. *Illænus giganteus*, Burmeister (*I. Lusitanicus*, Sharpe).
7. *Placoparia Zippei*, Boeck? (*Cheirurus* of former list).

Appendix D.—*Notes on the* Entomostraca.
By T. Rupert Jones, Esq., F.G.S.

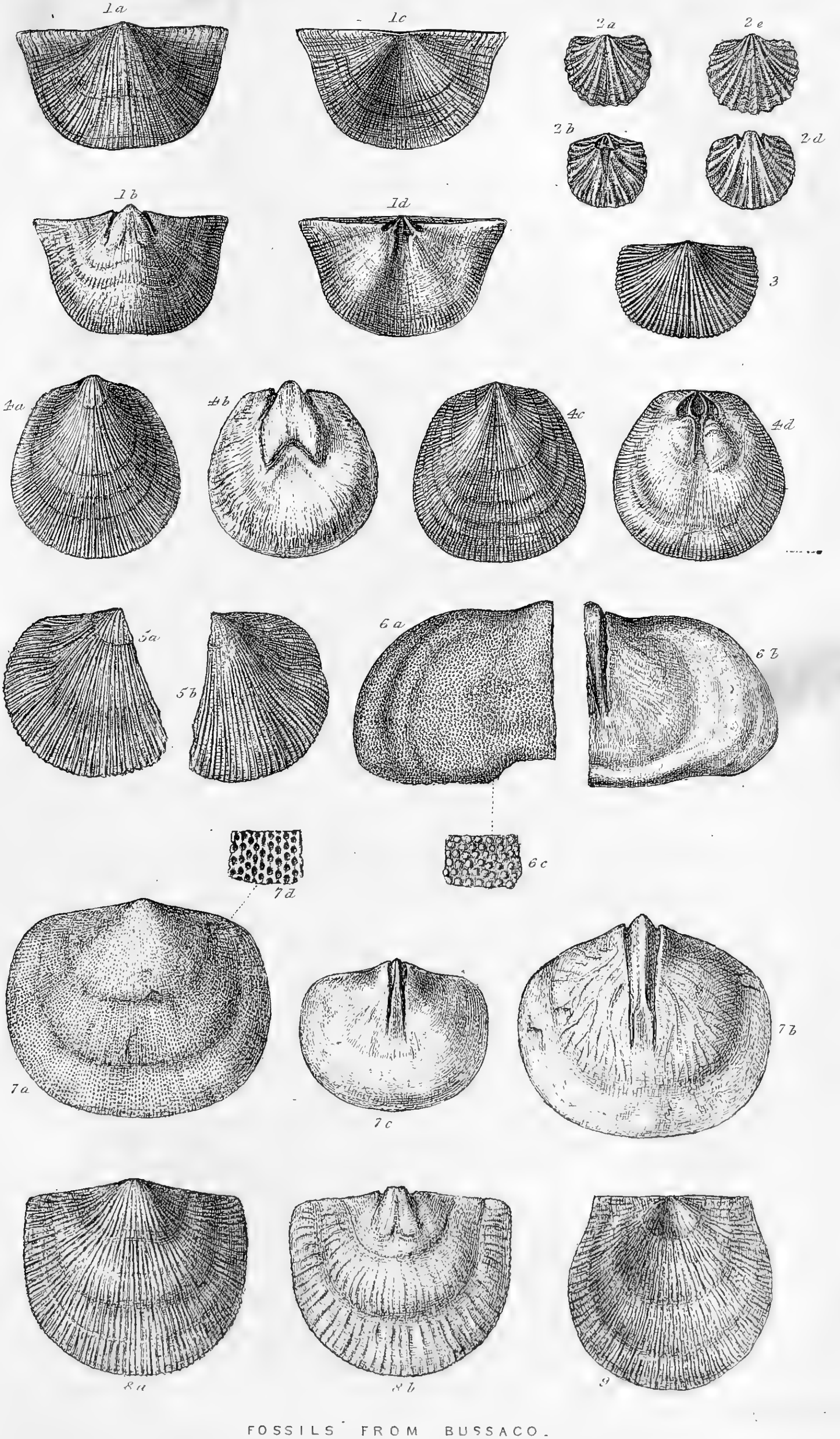
Beyrichia Bussacensis, n. s.

This *Beyrichia* abounds in a schistose rock from Porto de Louza, Serra de Bussaco, and from the Serra de Mucela, belonging to the Lower Silurian group, and is closely allied to *B. complicata* (Salter) of the Lower Silurian rocks of N. Wales. Casts and impressions of the valves are numerous, but specimens with the external surface are rare. Besides considerable variation in the disposition and relative proportion of the raised ribs and border, the Portuguese form differs from the specimens figured by Mr. Salter and Prof. M'Coy

* It may be remarked that the original species of Brongniart's genus *Ogygia*, *O. Guettardi*, has the characteristic labrum of *Asaphus*, and must be restored to that genus. *O. Buchii*, then, with its entire pointed labrum, will stand for the type of *Ogygia*.



FOSSILS FROM BUSSACO.



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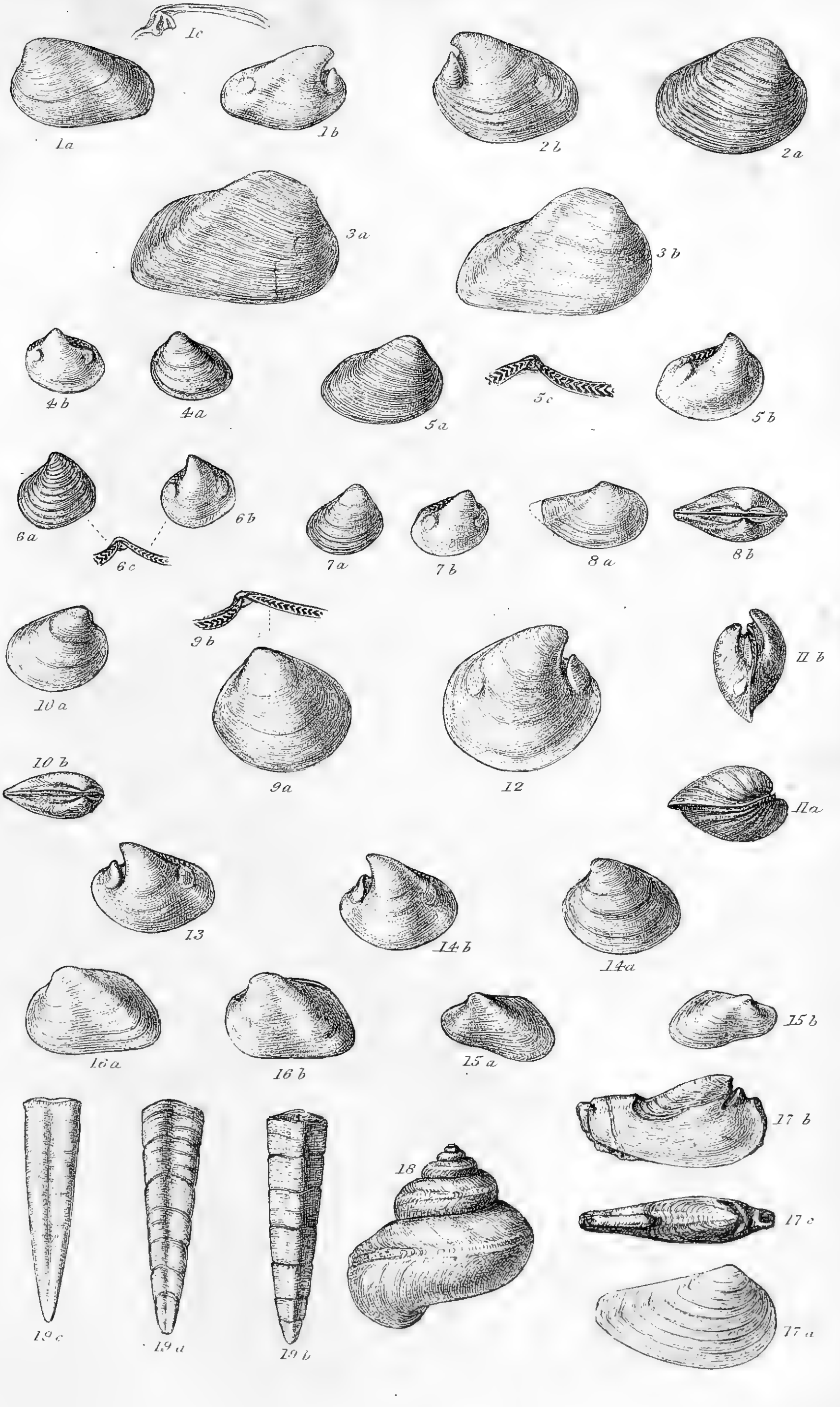
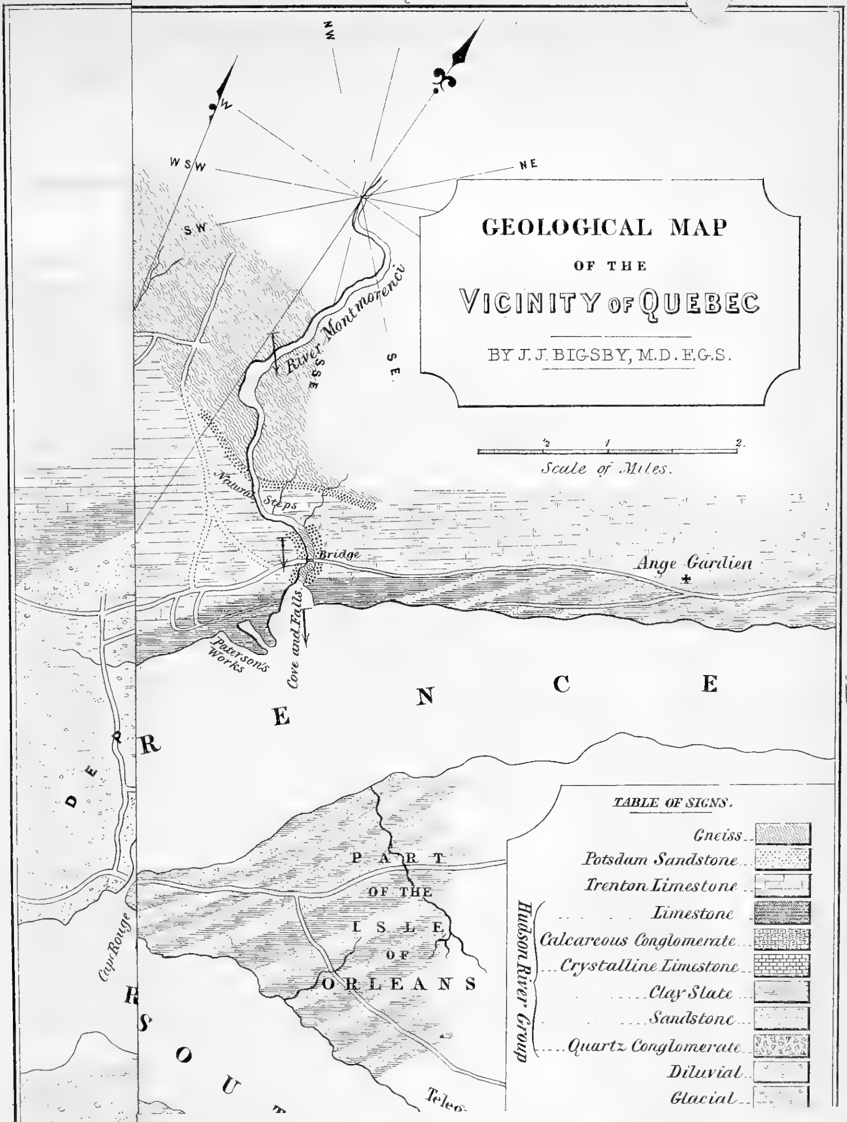
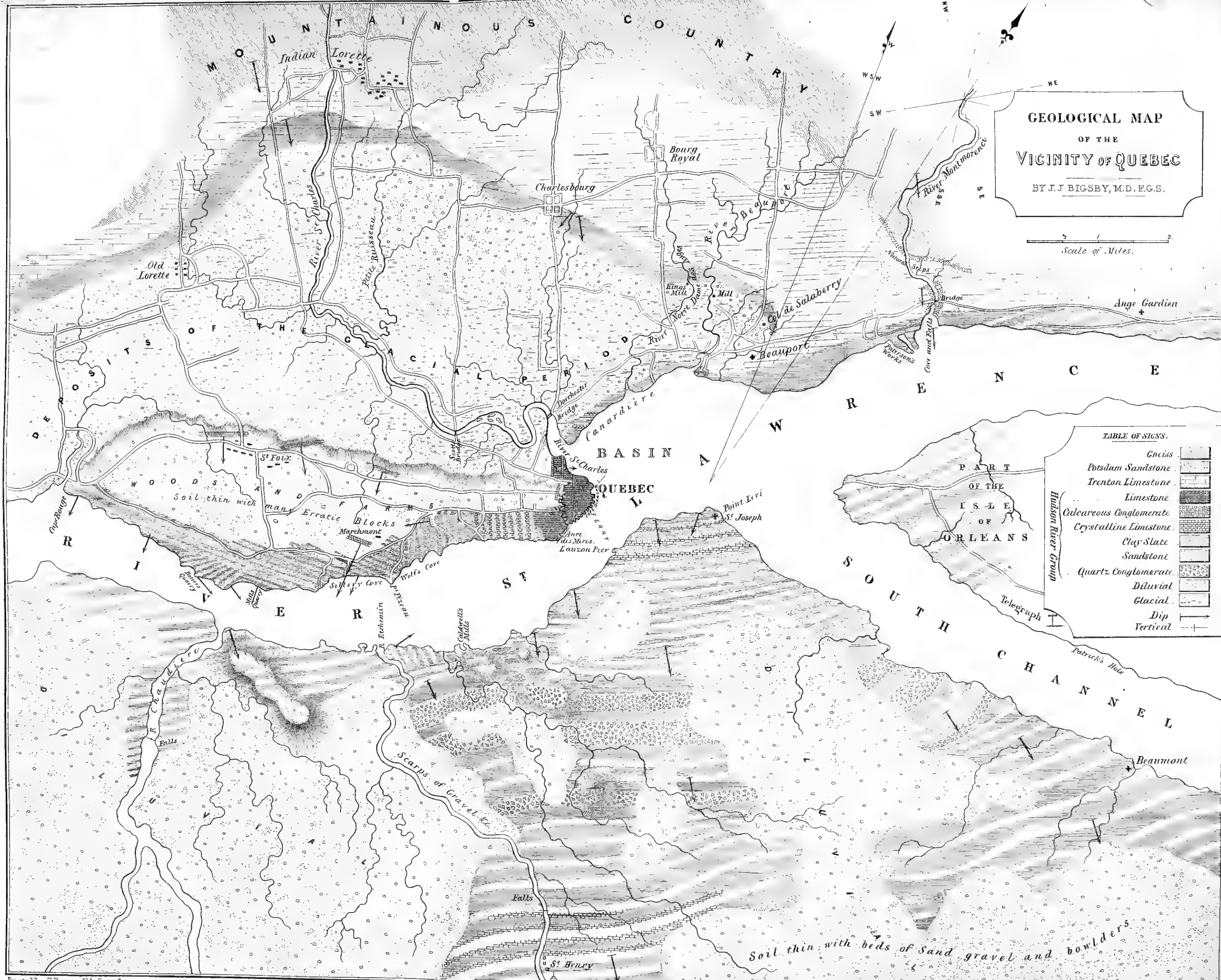


FOSSILS FROM BUSSACO.


GEOLOGICAL MAP
OF THE
VICINITY OF QUEBEC
BY J. J. BIGSBY, M.D. F.G.S.
Scale of Miles.
½
1
2.
NW
W
WSW
SW
NE
SE.
SSE
River Montmorenci
Natural Steps
Bridge
Ange Gardien
Paterson's Works
Cove and Falls.
R E N C E
D E
PART OF THE ISLE OF ORLEANS
Cap Rouge
R
S O U
Teleg
TABLE OF SIGNS.
Gneiss
Potsdam Sandstone
Trenton Limestone
Hudson River Group
Limestone
Calcareous Conglomerate
Crystalline Limestone
Clay Slate
Sandstone
Quartz Conglomerate
Diluvial
Glacial



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on Stone by C. Achilles

in being more angular at the extremities; in this and its straight dorsal edge, it nearly approaches the form of *Leperditia*.

PL. VII. fig. 5. Full-grown. Fig. 6. Young form.	External surface of right valve: D, dorsal edge; A, anterior extremity: *a*, nat. size; *b*, magnified.

BEYRICHIA SIMPLEX, n. s.

Broadly ovate, globose, smooth; ventral border rounded; dorsal border somewhat angular; hinge line oblique, about two-thirds the length of the valve; dorsal sulcus faintly marked on the anterior half of the valve. This is closely related to *Beyrichia Logani** and to *B. strangulata*, M'Coy, apparently forming a passage between this genus and *Leperditia*. Abundant in the same rock with *B. Bussacensis*.

PL. VII. fig. 7. Cast of the right valve: *a*, nat. size; *b*. magn.

EXPLANATION OF THE PLATES.

PLATE VII.

Fig. 1. Illænus giganteus, *Burm.*
Fig. 2. Placoparia Zippei, *Boeck, sp.*
Fig. 3. Dithyrocaris? longicauda, *Sharpe*; n. sp.
Fig. 4. Ogygia? glabrata, *Salter*; n. sp.
Fig. 5. Beyrichia Bussacensis, *Jones*, n. sp.
Fig. 6. —— ——, young.
Fig. 7. —— simplex, *Jones*; n. sp.
Fig. 8. Disteichia reticulata, *Sharpe*; n. gen. & sp.
Fig. 9. Synocladia Lusitanica, *Sharpe*; n. sp.
Fig. 10. —— hypnoides, *Sharpe*; n. sp.
Fig. 11. Pecopteris leptophylla, *Bunbury*; n. sp.

PLATE VIII.

Fig. 1. Orthis Ribeiro, *Sharpe*; n. sp.
Fig. 2. —— exornata, *Sharpe*; n. sp.
Fig. 3. —— Bussacensis, *Sharpe*; n. sp.
Fig. 4. —— Berthoisi, *Rouault.*
Fig. 5. —— Mundæ, *Sharpe*; n. sp.
Fig. 6. Porambonites lima, *Sharpe*; n. sp.
Fig. 7. —— Ribeiro, *Sharpe*; n. sp.
Fig. 8. Leptæna Beirensis, *Sharpe*; n. sp.
Fig. 9. —— ignava, *Sharpe*; n. sp.

PLATE IX.

Fig. 1. Redonia Deshayesiana, *Rouault.*
Fig. 2. —— Duvaliana, *Rouault.*
Fig. 3. Dolabra Lusitanica, *Sharpe*; n. sp.
Fig. 4. Nucula Costæ, *Sharpe*; n. sp.
Fig. 5. —— Ciæ, *Sharpe*; n. sp.
Fig. 6. —— Ribeiro, *Sharpe*; n. sp.
Fig. 7. —— Ezquerræ, *Sharpe*; n. sp.
Fig. 8. Leda Escosuræ, *Sharpe*; n. sp.
Fig. 9. Nucula Mäestri, *Sharpe*; n. sp.
Fig. 10. —— Eschwegii, *Sharpe*; n. sp.
Figs. 11, 12. —— Beirensis, *Sharpe*; n. sp.
Figs. 13, 14 —— Bussacensis, *Sharpe*; n. sp.
Fig. 15. Modiolopsis elegantulus, *Sharpe*; n. sp.
Fig. 16. Cypricardia Beirensis, *Sharpe*; n. sp.
Fig. 17. Ribeiria pholadiformis, *Sharpe*; n. gen. & sp.
Fig. 18. Pleurotomaria Bussacensis, *Sharpe*; n. sp.
Fig. 19. Theca Beirensis, *Sharpe*; n. sp.

APRIL 20, 1853.

Robert Death, Esq., and Arthur Phillips, Esq., were elected Fellows.

The following communications were read:—

1. *On the* PHYSICAL STRUCTURE *and* SUCCESSION *of some of the* LOWER PALÆOZOIC ROCKS *of* NORTH WALES *and part of* SHROPSHIRE. By Prof. ANDREW C. RAMSAY, F.R.S., F.G.S. *With Notes on the Fossils*, by J. W. SALTER, Esq., F.G.S.

THE Sections to which this notice refers are on a scale of 6 inches

* Referred to by me in Mr. Logan's Paper on Canada, *antea*, vol. viii. p. 207.

to a mile, vertically and horizontally. Section No. 1 passes from Mochras Island in Cardigan Bay, over Cader Idris, Radnor Forest, and Hanter Hill, to the Old Red Sandstone near Fern Hall, south of Kington, Herefordshire. It is about 65 miles in length.

No. 2 commencing at Llanfair-is-gaer, Menai Straits, passes over Snowdon, Moel-wyn, Gors-goch (near Trawsfynydd), Aran Mowddwy, and Newtown, Montgomeryshire, and the Upper Silurian rocks and Old Red Sandstone of Clun Forest, Wigmore Valley, &c., near Ludlow. It is 90 miles in length.

No. 3 passes across the Shelve and Longmynd country to the Brown Clee Hills*. These Sections were constructed by Messrs. Aveline, Selwyn, Bristow, and Ramsay; and the mapping of the county to which they refer was executed by them and Mr. Jukes.

Sections Nos. 1 & 2.—The oldest rocks crossed by Sections Nos. 1 & 2 lie at the base of the Merioneth anticlinal of Professor Sedgwick. They are the Barmouth and Harlech sandstones, which are here and there interstratified with beds of purple slate. Their base is not exposed, and the lowest beds that rise in the centre of the area are from 6000 to 7000 feet beneath the base of the Lingula flags. In places they are pierced by numerous greenstone dykes, a few of which are magnetic. No fossils have heretofore been found in them. These and their equivalents are the rocks coloured as "Cambrian" by the Geological Survey.

In Section No. 1 the whole of the black and ferruginous slaty and sandy beds that lie between the Barmouth sandstones and the volcanic ash on the north slopes of Cader Idris belong to the Lingula flags. They are about 7000 feet thick. Here and there, both in the line of section and in the neighbouring areas, masses of greenstone are protruded among them. These generally have a tendency to pass into the lines of bedding, but not unfrequently they cut somewhat across the strike, and divaricate into two or more branches. They are therefore known to be intrusive.

The slaty Lingula flags are succeeded in the ascending station by about 3000 feet of felspathic and calcareous ashes, here and there interstratified with bands of slate, indicating the successive accumulation of the ashy beds with periods of intermittent repose. They are often conglomeratic and brecciated, and sometimes give the impression that bombs have been shot from the volcano into the air, and fallen among the felspathic dust in a viscous condition. Much of the ash is also porphyritic. The crystals of felspar are always scattered and frequently fragmentary, and may have been showered out along with the volcanic dust and lapilli in the same manner that corresponding phænomena occur at the present day, it being known that the ashes of existing volcanos are often composed, in great part, of fragmentary crystals. It is said that perfect crystals of augite have been ejected in showers of ashes from Etna.

Two large masses of intrusive felspathic traps lie between the outcrop of these ashes and the estuary of the Mawddach. The higher

* The corresponding Horizontal Sections of the Geological Survey are sheets 26 & 27 for Section No. 1; sheets 28, 29, & 30 for No. 2; and sheets 35 & 36 for No. 3.

part of Cader Idris is composed of two masses of felspathic trap, between which there lie various interstratifications of slate, greenstone, and felspathic ashes. Where the section crosses the mountain, the lower felspathic trap lies on the north side of the cliff, and the other to the south-east of Llyn-Cae on the slope towards Tal-y-llyn. The slaty beds are hardened at the points of junction, and, though the traps appear to be perfectly interbedded, yet they are certainly intrusive, seeing that, though here separated from each other by about 2000 feet of rocks, they coalesce at short distances both on the N.E. and S.W. The same holds true of the greenstones.

The Bala and Llandeilo beds overlie these rocks, passing across the country south-east, in a series of rapid contortions, to the neighbourhood of Llanbrynmair, where the Caradoc sandstone comes in in a small trough, which is the equivalent of the first larger undulating trough of Caradoc sandstone in the country east of Aran Mowddwy, as shown in Section No. 2. The Bala beds are repeated on the east of the Llanbrynmair trough, and are again capped by Caradoc sandstone on the west slopes of Pegwns-fawr; beyond which, as far as the neighbourhood of Radnor Forest, the Caradoc sandstone, with troughs of Wenlock shale, is spread across the country in numerous anticlinal and synclinal axes. These troughs are all laid down on the Survey maps. In the area between Cader Idris and Llanbrynmair no fossils have been discovered. The author found a few Graptolites in equivalent slates near Machynlleth, and further south, at the Devil's Bridge, the Bala fossils found by Professor Sedgwick are well known.

The Cader Idris traps are continuous with those of Aran Mowddwy; and in that direction, after the two felspathic bands of Cader Idris join, it continues on one geological horizon to the northwards perfectly interstratified with the aqueous rocks of the country. The slates that underlie it at the Arans are porcelanized, and those that overlie it are unaltered; whence it is believed that the intruded rocks of Cader Idris pass northwards into what was once a true contemporaneous felspathic lava-flow. The Bala beds succeed the trap of the Arans. The Bala limestone is about 6000 feet above the trap, and between the limestone and the Caradoc sandstone on the east there are about 8000 feet of slaty beds, mingled with occasional sandstones. East of the Arans, therefore, the whole Bala or Llandeilo series seems to be about 14,000 feet thick. The Caradoc sandstone that overlies it is not less than 5000 feet thick. It seems to rest conformably on the Bala beds. This gives in thickness for all the rocks above described:—

Cambrian	6,000
Lingula and Bala beds, with igneous rocks interstratified	26,000
Caradoc Sandstone..................	5,000
	42,000 feet of

rocks seemingly deposited conformably on each other, the whole having been at later periods contorted and faulted together.

The ashes below the Aran traps are the equivalents of those of

Cader Idris. The Lingula beds lie underneath them between Aran Mowddwy and the Dolgelli and Bala road. They dip easterly at angles of from 50° to 60°. The section is unbroken, and the total thickness of these flags exposed is rather more than 6000 feet. They are cut off by a great fault, which passes from the borders of the Coal-measures, about six miles south-west of Chester, by Corwen and Bala lake, through Tal-y-llyn to Cardigan Bay. It appears to be covered up by the New Red Sandstone near Chester. From thence to the point where it enters the sea, the line is about sixty-five miles in length. It is invariably a downthrow on the *north-west*. On that side of the fault in the Bala country, Bala beds, traps, ashes, and Lingula beds are repeated in the same order in which they occur on the flanks of Aran Mowddwy. This constancy in the section proves the fault. From measured thicknesses, on Careg-llysog the top of the Aran trap must be thrown down to the level of the road, and the amount of the throw cannot be less than about 12,000 feet. The Barmouth sandstones must lie about 1000 feet beneath the surface at the Bala road. The supposed angles of the fault would scarcely affect these figures*.

Beyond the western outcrop of the ash-beds of Y-Dduallt, the Lingula flags crop out and undulate towards Gors-goch, near Trawsfynydd. Here and there they are pierced by masses and dykes of grey greenstone, often very felspathic. Near Trawsfynydd they abut against the Barmouth and Harlech sandstones. This fault cannot be less than 4000 feet. Near Trawsfynydd is the apex of the Merioneth anticlinal. Beyond that point towards Moel-wyn the rocks dip to the north-west. The boundary of the Barmouth and Harlech sandstones and the Lingula beds runs near the Tan-y-bwlch and Trawsfynydd road. The sandstones are succeeded by about 8000 feet of Lingula flags, if under this name we include the 3000 feet of flaggy mottled rocks that lie between the Ffestiniog syenite and Moel-wyn. These mottled rocks, however, on the south-west frequently pass into ash, and on the north-west by Manod-Mawr into sandstones and slates. The Ffestiniog syenite alters the rocks all around, in this respect being readily distinguishable from the contemporaneous felspathic traps which only alter the slates that *underlie* them. Above the mottled rocks there are beds of ash, conglomerate, felspathic slaggy-looking traps, and slates, all regularly interstratified.

On the south-east flank of Moel-wyn there are, in ascending order, first—350 feet of solid felspathic trap, then 120 feet of ashy conglomerate, then 130 feet of slate, which is succeeded by 180 feet of ashes. The ash is followed by 125 feet of slate, over which lies nearly 900 feet of slaggy felspathic trap, in some places columnar. The slates beneath these traps are altered by heat; those above are unchanged. This series occupies *the same general geological horizon* with the traps of Aran Mowddwy and the Arenigs†. Where unbroken by faults, they may be traced, as a mass, continuously about the top of the Lingula flags, circling round with the Merioneth anticlinal.

* See Horizontal Sections of the Geological Survey, sheet 29.
† See Horizontal Sections of the Geological Survey, sheet 28.

The succession in all the sections is the same, and the thicknesses nearly approximate to each other. The slates of the Ffestiniog slate-quarries succeed them. They lie in the lowest part of the Bala beds in their regular order of succession. The rocks at Tai-hirion, on the Bala road, near Arenig-bach, which contain *Trilobites* and *Lingulæ* (see Mr. Salter's note on the fossils, *infra*), are their equivalents. These *underlie* a set of ashy beds that form Arenig-bach and part of the country on the north that passes by Cerrig-y-lladion to the valley of Penmachno. An upper portion of this igneous series, therefore, belongs to the base of the Bala beds.

North-west of Moel-wyn, and in the country generally overlying the Ffestiniog felspathic traps towards Llyn Gwynant, numerous lines of greenstone occur. Like the same kind of intrusive rocks near Dolgelli, they are apt to run in the lines of bedding, but they also cut more or less across the strike.

No truly interstratified or contemporaneous traps occur between Moel-wyn and the Snowdon felspathic trap, which is 6000 feet by measurement *above* those of Moel-wyn and the other igneous rocks of the date of those of the Arans. All of these have heretofore been considered as belonging to one igneous group. The above thickness can be well measured on section No. 2. Notwithstanding the intruded lines of greenstones, the dip is steadily north-west as far as Castell and Yr-Arddu, which hills are capped by outliers of the Snowdon trap. The Castell trap lies in a synclinal of the Bala beds. The fault on the west, which repeats this trap, gives about 4300 feet of downthrow. The rock so repeated forms part of the great mass of the Snowdon trap, which from thence undulates westward in a great trough of about five miles in width*. It is about 1300 feet thick on the east side of Snowdon, but westward it splits into three thin bands of slate separating the masses. Above it lies about 1000 feet of calcareous, sandy, and felspathic ashes, largely intermingled with slaty sediment. Sometimes one element predominates, sometimes another: on the whole, the slaty and calcareous elements prevail. When this is the case, the rock is frequently fossiliferous. The fossils are those of the Bala limestone. Its position also proves that it is the equivalent of these beds; a conclusion long since arrived at by the Officers of the Geological Survey, first on physical, and afterwards on palæontological grounds. The traps and fossiliferous ashy beds of Snowdon and the true Bala limestone are each, therefore, about 6000 feet above the lower igneous series of Moel-wyn and the Arans†. The physical and palæontological evidence are thus in perfect accordance.

On the ridges of Crib-goch and Llewedd (parts of Snowdon), on Glyder fawr, and on Moel Hebog, near Beddgelert, there are eight small patches of another mass of columnar felspathic rock, that must once have entirely *overlaid* the ash. It may have been as large as the whole mass of the Snowdon trap that underlies it.

* This trough has been noticed by Prof. Sedgwick (Quart. Journ. Geol. Soc. vol. iii. p. 138).

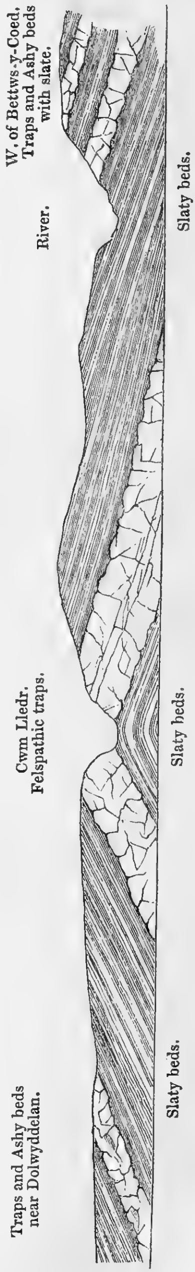
† Horizontal Sections Geol. Survey, sheets 28 & 29.

The Snowdon igneous rocks can be followed to Carnedd Dafyd, where certain lower beds of trap come in, interstratified with bands of fossiliferous slates and sandstones; these also form parts of Carnedd Llewelyn. Most of these rocks may be traced from Carnedd Llewelyn to Nant-francon, on the sides of the steep hill west of Llyn Ogwen called Braich-du. There they dip easterly at a high angle, and rise again with a westerly dip in the great peak of Y-Tryfan. From thence they roll over in a large anticlinal and form the heights of Gallt-y-gogo, on the south side of the Bangor road, within two miles of Capel-Curig. The two bands of slate that separate the igneous mass into three, cease in the valley of the Llugwy, and the trap becomes one thick band. This great band of felspathic trap can then be traced by Ffynnon Llugwy and Llyn Dulyn almost to Conway. It is broken here and there by faults. Its dip is invariably easterly. Above it, on the east, are beds of sandstone, slate, and felspathic traps and ashes. The sandstones, especially, are often fossiliferous, and contain the fossils common to Snowdon and Bala. These, with igneous interstratifications, extend with many contortions to the vale of the Conway. Their finest development lies between Ffynnon Llugwy and Llanrwst, around Llyn Cwlyd, Llyn Crafnant, and Llyn Geirionydd. Their position above the rocks of Y-Tryfan and Carnedd Llewelyn proves them to be the equivalents of the Snowdon traps and ashes, and their fossils are also the same. The calcareo-felspathic quality of some of the ashy beds nearly resembles some of the rocks of Snowdon and Y-Glyder-fawr. The slates and traps of Glyn Lledr (two miles south-west of Bettws-y-Coed) dip under the rocks that lie between Ffynnon Llugwy and Llanrwst. The Glyn Lledr rocks also dip under those in the Dolwyddelan Valley.

A reference to the published maps of the Geological Survey shows that the Snowdon trap bounds Nant Gwynant on the east. Together with the slates that immediately underlie it, it dips westerly,

Section from the River Llugwy, west of Bettws-y-Coed, to near Dolwyddelan.

Scale, 1 inch to 1 mile.



and, the whole rolling over in an anticlinal, the same traps and ashes are thrown across to Y-Foel-goch at the upper end of the Valley of Dolwyddelan*. Hence the highly calcareous ashes of that valley (almost a limestone in some places) are the precise equivalents of the Snowdon rock of the same kind, and also of the ashy beds towards Llanrwst; and all of these are, in parts, the equivalents of the Bala limestone and of the rocks immediately associated therewith. South-east of Bettws-y-Coed this limestone in its normal state actually appears, and, together with a thin associated bed of trap, it seems to bear the same relation, as regards superposition, to the Glyn Lledr traps, that the traps and ashes of Dolwyddelan and the neighbourhood of Llanrwst bear to the same rocks. There is, therefore, no doubt that the uppermost Snowdon rocks are represented by the limestone and its immediately associated strata, and the two extremely thin ashy beds that lie at some distance beneath it in the Bala country are all that remain to represent the thick igneous masses that spread across Caernarvonshire from Moel Hebog to Conway and Llanrwst, and which Section No. 2† proves to be about 6000 feet above the igneous rocks of Moel-wyn, just as the Bala limestone lies about 6000 feet above the *equivalents* of Moel-wyn,—viz. the igneous masses of Arenig and the Arans.

To return to the rocks that lie between Snowdon and the Menai Strait‡. On the sides of the Pass of Llanberis and of Nant-Francon, dark blue slates dip under the traps at angles of from 70° to 80°. Towards their base, sandstones and ferruginous slates occur, in which, at Marchlyn Mawr, I found *Olenus micrurus* and *Lingula Davisii*. These are the Lingula beds. The rocks that lie betwixt them and the Snowdon trap are therefore the representatives of the Bala beds that lie beneath the Bala limestone. No fossils have been found in them, neither does there appear in these sections any trace of the great igneous interstratifications of the Arans, the Arenigs, and Moel-wyns§. These have, therefore, entirely thinned out under the great Snowdon trough. As already stated, they dip northerly at Moel-wyn and the Manods, underneath 6000 feet of the lower Bala beds. Then the Snowdon trap and ashes come on, dipping to the north-west. They rise again in the Pass of Llanberis, but the igneous masses that *underlie* the Bala beds in the meanwhile *have entirely thinned away underground*; and this impossibility of tracing the beds is the reason why it has been heretofore supposed that the Snowdon traps were the equivalents of those of the Arans and of Cader Idris. The whole of the stratified series is much thinner on the Llanberis side of the trough than on the side of their outcrop towards Harlech and Ffestiniog. The Lingula flags, especially, are probably not of half the thickness; their upper limit, however, is uncertain.

From beneath the Lingula beds, both at Nant-Francon and Llanberis, sandstones crop out, which, it is well known, are the equivalents of the Barmouth and Harlech grits of Professor Sedgwick.

* Geological Map 75 N.E.

† Sheet 28 of the Horizontal Sections of the Geological Survey of Great Britain.

‡ Maps 78 S.E. and S.W.

§ Moel-wyn is in Map 75 N.E.

Here, however, they are largely interstratified with purple slates. They are in places much contorted, and, on this account, the thickness of slaty beds, as wrought in the quarries, appears much larger than in reality it would do, but for the repetition of the same beds by contortion. But little more than 2000 feet of these rocks rise to the surface by the sides of the Lake of Llanberis, whereas more than 6000 appear in Merionethshire.

The slates, I believe, are the equivalents of some of the sandy beds of Merionethshire. The sandy sediment has passed into mud, or *vice versâ*,—a phænomenon found to be of constant occurrence when we take in detail the strata of the Caernarvonshire development of these rocks, where slates, sandstones, and conglomerates in many places pass rapidly into each other. The interstratified sandstones and conglomerates are sometimes singularly inconstant. Most of them, even some of the more slaty conglomerates, are highly cleaved, and the pebbles are elongated in the lines of cleavage,—a circumstance remarked by Mr. D. Sharpe in regard to some of the rocks of Cumberland. Some of the conglomerates of Llanberis, in this the most ancient of the Welsh formations, contain pebbles of quartz, quartz-rock, felspathic trap, and quartz-porphyry, purple slate, black slate, red jasper, &c. They lie among the lowest exposed beds on the banks of Llyn Padarn, and the inference is undeniable that this conglomerate has been formed from the waste of a set of beds that formed some old land in many respects similar to Wales of the present day. The pebbles of purple slate resemble those of the very strata amid which they are found. The quartz-rock and jaspers resemble some of the metamorphic rocks of Anglesea, which metamorphism, it will be shown, probably took place subsequent to the deposition of this conglomerate; and the black slates and felspathic traps and porphyries are indistinguishable from those that occur about the base of the Bala beds in the district of Cader Idris, the Arans, the Arenigs, and Moel-wyn; or of the higher Bala beds in the heights of Snowdon, Carnedd Dafyd, and Moel Hebog*. In many of the pebbles of this old conglomerate there is no appearance of metamorphism, in the extreme sense of the term, as applied to foliated rocks; in others metamorphism may have occurred.

In a large sense of the term, I know of no *formation* in England or Wales of older date than these Cambrian slates, sandstones, and conglomerates; and the facts above described therefore, more than in any other case with which I am acquainted, prove that the same kind of slates, purple and black, of porphyries, and of metamorphic rocks formed some land of which we should have had no knowledge were it not that its former existence is revealed in the structure of these conglomerates. The oldest formation now known in Wales, therefore, does not represent the beginning of those phænomena of ordinary deposition, of ordinary volcanic action, and of metamorphism, which last in this, and in other parts of Europe is characteristic of many epochs in time as high at least as the Eocene rocks

* There can be no mistake about the position of these conglomerates. They distinctly underlie the whole of the workable beds of purple Cambrian slate.

of the Alps. We can find no beginning to the existing order of physical phænomena.

To the west of the intruded porphyry that ranges from Llanllyfni to St. Ann's Chapel, near the Penrhyn quarries, a fault, that runs from Aber to Dinlle, again throws in the Lingula beds and probably the lower part of the Bala series. The down-throw varies in amount from 2000 to 6000 feet *. East and south of Bangor the greenish sandstones and green and purple slates again crop out from beneath the Lingula shale. They are much altered by the intrusion of an igneous rock which runs from Bangor to Caernarvon. It is composed of quartz and felspar, sometimes well crystallized. Such rocks have been sometimes termed "Granitella." By the addition of mica this rock at Caernarvon would become a perfect granite. This rock is also cut off by a downcast fault on the north-west, by means of which the Carboniferous Limestone and part of the Coal-Measures abut on the trap. A conglomerate forms part of these Carboniferous rocks, seemingly formed from the waste of the traps and palæozoic rocks of the neighbourhood. Some of the pebbles are much altered. Such metamorphism as the older palæozoic rocks had undergone took place, therefore, before the Carboniferous period. The base of the Lingula shales, which at Bangor lies on altered chloritic green and purple sandstones and slates, strikes across the Menai Straits, a little west of Beaumaris, where they lie on chloritic schists and sandstones still more metamorphosed. It is believed that all the rocks of Anglesea coloured light pink on the Survey Maps belong to the same series as the Barmouth and Harlech grits, and the Llanberis and Penrhyn green and purple sandstones and slates, but, the rocks being generally much metamorphosed, the colouring on the map is changed to express such an alteration. At Bangor the same beds graduate by alteration into rocks of the Anglesea type, and the typical Cambrian colour is shaded on the map into that which expresses Metamorphic Cambrian. The dark blue shales and grey sandstones and conglomerates of Anglesea, coloured pink on the map, represent Lingula beds and part of the Bala or Llandeilo rocks. Near Amlwch two masses of granite are intruded among them, and the strata surrounding them have been changed into mica-schist and gneiss. A patch of Old Red Sandstone on the coast opposite Yuys-dulas rests unconformably on these altered rocks. *It has been formed by their waste and by that of the intruded granite.* The date of the metamorphism was therefore prior to the deposition of the Old Red Sandstone, and the country had also at that time been already much denuded to admit of an originally deep-seated granite being exposed to the wasting action of water at the surface. The metamorphic rocks on the north-west side of the great Caernarvonshire promontory are believed to be the equivalents of the same species of rocks in Anglesea, and of the Barmouth and Harlech grits, &c. The strike of the latter beds near Clynnog-fawr would lead to the inference that the Porth-dinlleyn metamorphic beds are the equivalents of the Llanllyfni purple slates, and of the highly altered sandstones of Glynllifon. Half-way between

* See Geological Survey Maps, 78 S.E. & S.W.

these points the slates of Trwyn-y-tâl on the coast dip southerly. They contain pisolitic iron-ore, and belong to that part of the Lingula flags in which the pisolitic iron-ore of Llyn Cwellyn (above the road from Caernarvon to Beddgelert) occurs. Iron-ore, probably on the same parallel, again crops out in the black shales between St. Tudwall's Road and Hell's Mouth. They dip northerly, and the rocks, therefore, that occupy the midst of the promontory, lie in a trough, and belong to part of the Bala series. The fossils of the district confirm this idea. Wherever any junction of these beds and of the metamorphic schists is exposed, they are always found to be brought against each other by faults. Greenstones, felspathic porphyries, and syenites are intruded in great bosses amid the above-mentioned strata.

Recapitulation.—Such is a brief outline of the disposition and structure of the rocks of North Wales that lie beneath the Caradoc Sandstone. I shall briefly recapitulate the sequence. The lowest rocks are the Barmouth and Harlech grits, or their sandy and slaty equivalents of Llanberis and Penrhyn, which are also the equivalents of the main masses of metamorphic strata of Anglesea and the north horn of Cardigan Bay. Their greatest known thickness is about 6500 feet. Then come the Lingula beds, about 7000 feet in thickness. Both of these are pierced by greenstone dykes, and by bosses of intrusive greenstone, syenites, and felspathic traps. Toward the close of the Lingula flag depositions volcanic outbursts took place, in consequence of which great ashy deposits were formed interstratified with ordinary muddy sediment, and here and there associated with thick beds of felspathic lava. It has been stated that these rocks forming the Arans and the Arenigs are on different horizons. This has not been found to be the case. They are all on the same horizon and merely repeated by faults. Numerous greenstones are associated with them, especially among the ashes. Although these often run in the lines of bedding for a space, yet they frequently break suddenly across the strike, and are therefore intrusive. Much of the ash seems to have been subaërial. Islands, like Graham Island, may have sometimes raised their craters for various periods above the water, and by the waste of such islands some of the ashy matter became water-worn,—whence the ashy conglomerates. Viscous matter seems also to have been shot into the air, as volcanic bombs, which fell among the dust and broken crystals (that often form the ashes) before perfect cooling and consolidation had taken place. The volcanic activity ceased for a time, during which 6000 feet of the lower Bala beds were accumulated. It then broke out afresh in a new area, further north, and the volcanic rocks of Moel Hebog, Snowdon, Carnedd Llewellyn, Conway, &c., were produced. Numerous lines of intrusive greenstone occur in the slates that lie between these two great igneous series. They often run in the line of strike, but they also sometimes cut across it and branch into two. The rocks also both below and above are altered, which is never the case with the slates that rest on the contemporaneous felspathic lavas. The great centre of this later volcanic outburst was in the Snowdonian range.

The faintest traces of its ashes are associated with and underlie the Bala limestone in the Bala country. The great centre of the older volcano or volcanos was further to the south-east.

Now it is worthy of remark, that the great bosses and lines of intruded felspar- and quartz-porphyries, greenstones, and syenites are always found in rocks as old as or older than the rocks with which the ashes and lava-flows are associated. My belief, therefore, is that they form the original deep-seated nuclei that were connected underground with the volcanic rocks that in this neighbourhood are interstratified with the Lingula and Bala beds. Further, that the long lines of greenstone that are associated with the rocks lying between Snowdon and Moel-wyn bear the same relation to the Snowdon volcanic series that similar greenstones do at a lower level to the volcanic series of the Arenigs and Arans; and that, instead of being contemporaneous, as implied by Professor Sedgwick, they merely originated in melted matter, being injected and burrowing into lines of weakness deep underground during two periods of volcanic activity, and that both they and the greater masses of intrusive porphyry and syenite have all been subjected to those subsequent forces that bent and contorted the whole of the ancient palæozoic rocks. From an examination of many sections, I have no doubt that the greater intrusive nuclei partially partake of these contortions, because in the upward progress of the melted matter towards the volcanic mouths it sometimes was more or less injected in great sheets somewhat in the lines of bedding, while sometimes it broke across the beds with comparative abruptness. When in sheets, there is no reason why it should not have been equally bent with the thick masses of truly interstratified porphyries. They are certainly affected by faults in the same manner as the strata, and if so, they can in no sense be looked upon as the cause of the great disturbances that contorted and faulted the country. These were of later date.

I have said that the intrusive traps are of the same general dates with the interstratified igneous rocks. The mass that runs from St. Ann's Chapel to Llanllyfni is a quartz-porphyry. Crystals of quartz are imbedded in a felspathic base. The neighbouring mass, nearer the Menai, often much resembles it, but is also much more granitic in texture. The Anglesea granite often quite resembles the Menai igneous rock, and sometimes by addition of mica becomes a true granite. There is no reason why they should be referred to different dates, and, if the previous conclusions be correct, then the granite is of Lower Silurian date, and the metamorphism of at least part of the Anglesea rocks took place at one of the previously mentioned periods of volcanic activity, and probably at a depth of not more than from 8000 to 10,000 feet beneath the surface*. As the granitic rocks of Anglesea and the Menai break out at many places and at many different levels, there is reason to conclude that the island generally is underlaid by a great mass of granite; and, if this be so, then it may be probable that all the altered rocks of Anglesea were principally

* The Lingula flags and superincumbent Bala beds thin out considerably between Bala and the Menai.

metamorphosed during the Lower Silurian period. The foliation of the Anglesea rocks is probably a result of this metamorphism, and this may account for the fact that this foliation lies not altogether, but exceedingly frequently, in or approximately in the direction of the lines of bedding; for it must be recollected that the principal cleavage of the Silurian and Cambrian strata of Wales took place at a period long subsequent to the date of the volcanic and supposed metamorphic phænomena. The whole of the strata that have heretofore been mentioned in this memoir, and also the igneous, were bent and distorted before the great cleavage of the country began; but the foliation of the rocks of Anglesea was of prior date*.

It is not intended to be implied in the above remarks that foliation in all cases generally follows the planes of bedding, but only that, if the rocks be uncleaved when metamorphism takes place, the foliation planes will be apt to coincide with those of bedding; but, if intense cleavage has occurred, then it may be expected that the planes of foliation will lie in the planes of cleavage†.

Section No. 3. *The Longmynd district.*—It is foreign to my present purpose to enter on descriptions of the Berwyns. It has been already shown by Professor Sedgwick, and confirmed by the Officers of the Geological Survey, that the Berwyn rocks partly represent the Bala Series. I may now add, that it seems possible to trace the evidences of both the igneous series of Merionethshire and Caernarvonshire in these rocks. Neither shall I enter on any description of the Caradoc sandstone and Wenlock and Ludlow rocks that run from the neighbourhood of Conway to the country south-west of Builth. The Builth rocks and those of the Shelve country, associated with igneous rocks, are well known, from the descriptions of Sir Roderick Murchison and other authors, to form part of the Llandeilo or Bala group, and there can be no doubt that the Longmynd rocks bear the same relation to the lowest black slates below the Stiper Stones, that the Barmouth and Harlech grits do to the Lingula flags of Merionethshire. One important result, however, has arisen in the construction of the sections across the Longmynds by Mr. Aveline,—I allude to the thickness of the strata.

Between the Church-Stretton valley and the country from half a

* There is no doubt that in many cases the foliation of the Anglesea rocks runs much across the dip of the strata. The author hopes to enter on the subject more at large in a subsequent communication.

† See Ramsay's Geology of Arran, 1841, pp. 88 and 89, where foliation is described as having taken place approximately in the planes of bedding. The word "foliation," not having been then invented, is not used, but the phænomenon is described. In 1846 Mr. Darwin, in his 'Geology of South America,' takes notice of the probability of foliation being found in the general direction of the planes of bedding and oblique lamination, and minutely and ably describes the passage of cleavage into foliation. His remarks on this subject form a perfect model of the true mode of investigating the subject.

It is worthy of remark, that the foliation of the schists of Arran took place previously to the deposition of the Old Red Sandstone. The Grampian rocks were also altered before that date, for the Old Red Sandstone contains pebbles of the altered rocks. May it not be that the granites and syenites of these districts are of the same age as those of Wales, viz. of Lower Silurian date?

mile to a mile east of the Stiper Stones lies the hilly tract of the Longmynds*, long ago referred by Sir Roderick Murchison to the Cambrian strata. The Geological Survey has adhered to this nomenclature. No fossils have been found in these rocks. The main mass of the rocks constitute a block of country about 8 or 9 miles long by about $5\frac{1}{2}$ miles wide. A long spur of the same rocks protrudes from the principal block as far as the ancient camp four miles N.E. of Shrewsbury. It is nearly continuous, and about eleven miles long. Between Le Botwood, Shrewsbury, and the Camp it is partly overlaid by the Coal-measures, partly by the Lower New Red Sandstone. On the south the Wenlock shale overlies it unconformably, and on the west it is overlaid conformably by the black Silurian shales that underlie the Stiper Stones. On the east it is bounded by a great N.E. and S.W. fault that runs from the New Red Sandstone near Uppington ($7\frac{1}{2}$ miles E.S.E. of Shrewsbury) to the neighbourhood of Gladestry between Builth and Kington. The fault extends about 45 miles. South of Church-Stretton the throw is about 2000 feet. West of the fault the rocks of the Longmynd country generally dip W.N.W. at angles varying between 50° and 80°. Contortions are few, and there is no positive appearance of a complete doubling up of any portion of the country with subsequent denudation of the curve. The entire thickness between the Church-Stretton fault and the western boundary, carefully measured (see the Sections of the Geological Survey, sheets 33 and 36), is about 26,000 feet. The superficial area that these rocks occupy is small; their thickness is as great as or greater than that of any one division of rocks heretofore measured in Britain. The Llandeilo flag-beds with their igneous interstratifications lie on these in perfect conformity, and between the neighbourhood of the Stiper Stones and Chirbury (where the Llandeilo flags are overlaid unconformably by the Wenlock shale) they attain a thickness of about 14,000 feet. The entire thickness of conformable strata between the Church-Stretton fault and the Wenlock shale at Chirbury is 40,000 feet, and on the west we do not reach the top of the Llandeilo beds, because of the unconformity of the Wenlock shale; while on the east we do not reach the base of the Cambrian strata, because they are cut off by the Church-Stretton fault†. The Longmynd rocks are often hardened, brittle, and flinty in appearance, but they are by no means metamorphosed, even at the bottom, in the sense in which the term "metamorphic" may be applied to the rocks of Anglesea. There is nothing gneissic or foliated in their structure. The old Huttonian doctrine, therefore, that rocks may be expected to be metamorphosed in proportion to their age and the depths to which they have been depressed, is not always a safe guide. The lowest rocks near Church-Stretton have been buried at least four times deeper than the Anglesea rocks were, before the deposition of the Wenlock shale, and they are less altered than many of the rocks of Anglesea and Caernarvonshire.

Roughly estimating the increment of heat in proportion to increase

* See Geological Survey Maps, 60 N.E. and S.E., and 59 N.W. and S.W.

† Horizontal Sections of the Geological Survey, sheet 36.

of depth, and supposing the same rule that is now approximated to by physicists obtained when the rocks were formed, the lowest beds of the 40,000 feet thickness would not be heated beyond 700°, unless indeed other Lower Silurian strata, now concealed by the Wenlock shale, still increased the pile.

Various igneous rocks come through in the main fault, or in the minor dislocations that accompany it. They occur near Kington, at Hanter Hill, Old Radnor, and Stanner Rocks; and near Church-Stretton, at Cardington, Caer Caradoc, and the Lawley, and, still further north, at Dryton Bank, Charlton Hill, Brockwardine, and the Wrekin. These traps are altogether of a different date from those of North Wales, Builth, the Breidden Hills, and the Shelve country. All these are of the close of the Lingula flags, or else belong to the age of the Llandeilo or Bala period. But the traps that come through in the great line of the Church-Stretton fault are of the date of that dislocation, viz. at some time after the close of the Silurian period. Near Church-Stretton the Caradoc Sandstone is highly altered by these traps. Near Kington the traps alter Caradoc Sandstone on Old Radnor Hill, and Ludlow rocks near Hanter Hill. The date of the origin of the fault is unknown. It is later than the deposition of the Coal-measures, because they are affected by it. It is also later than the New Red Sandstone, because it runs into that formation. It is probably of various dates, and its present amount may be the result of various throws. The Caradoc Sandstone east of Caer Caradoc is *altered* by the trap. The Wenlock shale which is brought against the west side of Caer Caradoc by the fault is *unaltered.* The downthrow has been increased probably on that side since the melted matter was first injected into the crack. In the Permian rocks, in the neighbourhood of the Forest of Wyre, part of Staffordshire, and round the Abberleys, there is a trappean breccia, many of the fragments of which seem more likely to have been derived from the traps about Church-Stretton, &c. than from any other known rocks. If the conjecture that they have been derived from the waste of these rocks be true, then not only have the traps been injected into a dislocation of older date than the Permian æra, but also denudation has gone on to such an extent, that these originally deep-seated masses have been then exposed at the surface while Permian strata were being deposited. But the fault passes into the Bunter or Upper New Red Sandstone, and this may be on account of a repetition of throw in the old line of dislocation.

There is one other point to notice with regard to the Longmynd country:—in April 1848 Mr. Aveline and myself described in the Journal of the Society two bands that underlie the Wenlock shale where it bounds the Longmynds on the south-east and south. The uppermost is a band of limestone, the lower is a band of conglomerate, then called Caradoc Sandstone, and which is there correctly said to rest "unconformably on the Longmynd Cambrians, in such a manner that it is plain the latter formed an original boundary of the sea of the period." I may now state that we are agreed to modify that part of the opinion there given which unequivocally refers this thin

band of rock to the Caradoc formation. The fossils it contains, as noted by Professor E. Forbes, are mentioned in the Journal of the Society, vol. iv. p. 297–299. They are generally the same as those in a band of limestone that occurs between the Caradoc Sandstone and the Wenlock shale west of Wenlock edge. These fossils have always been considered as characteristically "Caradoc," nevertheless the rock that contains them is physically connected with the Wenlock shale. It is conformable with the Wenlock beds and rests unconformably on the Caradoc Sandstone, and (associated with the Wenlock shale) it entirely overlaps the latter in a distance of less than two miles between Acton Scott and the Longmynds. It was the sandy and pebbly beach of the Wenlock sea; and, just as in the Llandeilo flags at Castell Craig Gwyddon, in Caermarthenshire, and other places, where sandy and pebbly Caradoc-looking beds occur, there is an occurrence of Caradoc Sandstone fossils, so in this coarse littoral development of part of the Wenlock series the life of the Caradoc times seems for a season to have been partially prolonged. The typical Caradoc Sandstone of Shropshire is essentially a sandy deposit, and seems to have been mostly accumulated in shallow water. Under similar conditions, whether in Llandeilo Flag pebble banks or in Wenlock beaches, Caradoc-looking assemblages of fossils may occur. In such cases they form an exceptional development; they are not the rule, for the mass of the Wenlock shale is a deep sea deposit. The Longmynd and Shelve country (Llandeilo) stood above water when it began. They were gradually depressed, and, as the depression progressed, the beach crept inland until the old island was entirely encased and buried under the Wenlock shale. The outlying patches of sandstone, therefore, on the high land near the Bog Mine, Shelve, are part of a Wenlock beach of somewhat later date than the conglomerates and limestones that underlie the Wenlock shale at lower levels on the south of the Longmynd. Scattered pebbles of these rocks (the remains of denudation) strew many parts of the surface of the Shelve country and of the Longmynds.

It must always be borne in mind that the relative height of the Longmynds to the Wenlock sea was very different from that which the rocks on the opposite sides of the fault now maintain to each other. The Church-Stretton fault is a downthrow on the west of at least 2000 feet, and, the fault having taken place at a late geological period, the Longmynds were probably at least 2000 feet higher (as regards the Wenlock rocks, while these were being deposited), than the height they now maintain with reference to that formation. This would materially modify the conditions of deposition, and the Longmynds must have stood out amid the waters as a bold and rocky islet, from the waste of which in part the Wenlock littoral sandstone beds of Shropshire were derived.

Denudation.—The denudation which North Wales and parts of Shropshire have undergone is of vast amount. To describe it fully would itself occupy a long memoir. It is worthy of remark, however, that, as shown in the Shelve and Longmynd country and in the neighbourhood of Builth in Radnorshire (see Sections of the

Geological Survey, sheets 5, 6, and 36), the Cambrian and Llandeilo rocks had suffered immense denudation before the deposition of the Wenlock shale, which rests often nearly at right angles on the upturned edges of the older rocks.

Respecting other and, in great part, later denudations, that of the Merionethshire district is at first sight the most remarkable, and is therefore here mentioned by way of a special example. From the lowest exposed beds of the Cambrian strata to the top of the Snowdon rocks on one side, and to the Bala limestone on the other, there is at least a thickness of 23,000 feet. All this has been removed by denudation, for the sequence of rocks round the Cambrian central axis is perfect and quite conformable; and, for the reason, that, if we could sink deep enough through the Snowdon and Bala rocks, we should certainly arrive at a given depth at the Harlech grits; there can be no doubt that originally these grits were covered by the Lower Silurian strata, that surround them in Merionethshire, on the south, east, and north. Indeed, so far from the rocks that form Snowdon (the Bala beds) being the highest rocks that originally overlaid the Merionethshire Cambrians, there can be little doubt that the additional 8000 feet of strata that lie above the Bala limestone must also have been once continuous across this space; and the amount of matter removed, and, perhaps, the curves of the strata during the process of denudation, may be deduced from the arrangement of the beds as shown in the published geological sections of this part of North Wales, which have been drawn with much accuracy of detail.

Respecting the amount of matter removed; I believe that the subject should be treated in the same manner that the author has already dealt with the denudation of South Wales and Somersetshire*. This can only be done by the employment of sections on a corresponding vertical and longitudinal scale. Numerous other questions in geological physics will by-and-by be opened out and settled by this style of work,—questions that it is rash to touch upon with data less perfect than such sections afford.

* Memoirs of the Geological Survey of Great Britain, vol. i. p. 297.

NOTES *on the* FOSSILS. By J. W. SALTER, Esq., F.G.S.

The 'Lingula Flags' contain, at Dolgelly, Trawsfynydd, Ffestiniog, and Tremadoc, as stated in the Reports of the Brit. Assoc. 1852 (Trans. Sect. p. 57),

Hymenocaris vermicauda. Olenus micrurus. Lingula Davisii.

The last ranges upwards through a great part of the igneous series.

Near Llanberis and Bangor the *Olenus* and *Lingula* are still found, and with them two fucoids,

Cruziana semiplicata. Chondrites acutangulus?

Fucoids are also said by Prof. Sedgwick to abound at Tremadoc, Ffestiniog, and Dolgelly.

In the black slates at Pont Seiont, Caernarvon, there occur

Fragments of Crustacea, and Graptolites (Didymograpsus Murchisonæ?);

and at the Bath-house, Bangor, in similar black slates,

Bellerophon perturbatus (Euomphalus, Sil. Syst.), a single specimen.

The higher parts of the igneous series have yielded fossils at two or three points only:—Tai-hirion, Arenig-bach; and four miles N.E. of Dolgelly.

Asaphus Selwynii. Calymene parvifrons. Lingula—probably L. Davisii.

The black slates above the igneous rocks of the Arans and Arenigs, though well-adapted for the preservation of Graptolites, have yielded scarcely any, but in their lowest beds, immediately over the igneous rocks of Arenig-bach, are numerous fossils, first discovered by Professor Ramsay, and exactly like those of Bala, mentioned below.

The Snowdonian slates, as exhibited in the Pass of Nant Francon, are full of fossils—occurring in five or six bands between the beds of ash and felspathic traps; and are all of species common in the Bala limestone, and distinct from those of the Lingula beds below. Prof. Sedgwick has described this great "fossiliferous trough, half a mile wide, which ranges from this point through the highest parts of the Caernarvon chain," and has given some of the fossils.

Calymene Blumenbachii and C. brevicapitata,
Homalonotus bisulcatus,
Lichas laxatus,
Trinucleus concentricus,
Beyrichia complicata,
Tentaculites annulatus,
Strophomena expansa* and S. depressa,
Orthis flabellulum* and O. elegantula,
Leptæna sericea,
Rhynchonella serrata*,
Murchisonia scalaris*,
Turbo crebristria,
Bellerophon ornatus, and B. carinatus?*,
Modiolopsis, 2 or 3 species,
Stenopora fibrosa,

are the prevailing fossils, and all but one are common at Bala.

* These are in great abundance.

The characteristic fossils of the Bala limestone and slates have now been often quoted. Those in the limestone itself are ordinarily distinct from those found in the more sandy strata above and below; but in the more earthy parts of the limestone this distinction is lost: the following may be considered quite characteristic of the group:—

Fossils of the Bala limestones.	*Fossils of the sandstones and ash-beds.*
CRUSTACEA.	
Trinucleus seticornis.*	Trinucleus concentricus.*
Illænus Davisii.	Illænus Bowmanni.
Cybele rugosa.	Asaphus Powisii.*
Encrinurus sexcostatus.	Phacops apiculatus.*
Phacops alifrons, rare.	—— conophthalmus.
Calymene Blumenbachii, rare.	Calymene brevicapitata.*
Lichas laxatus.*	Lichas laxatus.
Cheirurus bimucronatus.*	
—— octolobatus.	
—— clavifrons.	
Ampyx tumidus.*	
Agnostus trinodus.	
Remopleurides radians.	
Cythere, 2 small species.	Beyrichia complicata.*
MOLLUSCA.	
Oncoceras, 2 or 3 species.	
Lituites cornu-arietis.	
Holopea, 2 or 3 species.	Turbo crebristria.*
Murchisonia scalaris.	Murchisonia scalaris.*
Orthis biforata.**	Orthis biforata.*
—— Vespertilio.*	—— Vespertilio.*
—— calligramma (plicata, Sil. Syst.).*	—— calligramma (plicata).*
—— Actoniæ.*	—— flabellulum.*
—— elegantula.*	—— elegantula.*
Leptæna sericea.*	Leptæna sericea.*
—— tenuicincta.	
—— quinquecostata.	
Strophomena tenuistriata.*	Strophomena depressa.
Crania divaricata.	—— orthisoides.
RADIATA.	
Cystideæ—several species.*	
Encrinite stems, abundant.	Glyptocrinus basalis.*
Stenopora fibrosa.*	Stenopora fibrosa.*
Retepora Hisingeri.	Retepora Hisingeri.
Ptilodictya fucoides.	Petraia subduplicata.

The same fossils are repeated, species for species, on the opposite or eastern side of the trough of Caradoc sandstone, at Llanfyllin, Llanwyddyn, Meifod, &c.; and the calcareous bands S. of Llangollen present the same assemblage, with some trifling variations, and with a larger proportion of corals.

The fossils of the Hirnant or Upper Bala limestone have been enu-

* The abundant species are indicated by asterisks.

merated by Prof. M'Coy; they are few in number and peculiar. The slates that occur at the top of the Bala rocks in the neighbourhood of Llanfyllin and Meifod contain several species identical with those of Bala, but their fossil contents are not yet fully worked out. There are many Upper Silurian species, as already stated by Prof. Sedgwick, and occasionally *Pentamerus oblongus.*

Lastly, the Caradoc sandstone of Denbighshire, taken at three localities not far from Llanrwst, presents the following fossils:—

Calymene Blumenbachii.	Strophomena compressa.
Phacops caudatus.	—— depressa.
—— Downingiæ.	Atrypa reticularis.
Beyrichia tuberculata.	Rhynchonella nucula.
Holopella gregaria.	—— borealis?
Mytilus unguiculatus.	Chonetes sarcinulata.
Clidophorus ovalis.	Spirifer plicatellus.
Nucula levata?	—— elevatus.
Leptæna sericea.	Arca Edmondiiformis.
—— transversalis.	Encrinite stems.
Orthis elegantula.	Favosites alveolaris.
—— virgata?	Stenopora fibrosa.

These fossils are by no means characteristic of the "Caradoc sandstone of Shropshire" [now ascertained to belong to the Bala and Llandeilo group, July 1853], and, with few exceptions, are species found in Upper Silurian strata. Prof. Sedgwick formerly referred these beds, on fossil evidence, to the Wenlock shale (*antea*, vol. i. p. 21).

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2. *On the Occurrence of* Caradoc Sandstone *at* Great Barr, South Staffordshire. By J. Beete Jukes, Esq., M.A., F.R.S., F.G.S.

Shortly after the publication of my memoir on the Geology of the South Staffordshire coal-field in the 'Records of the School of Mines' (vol. i. part 2), I received a note from Mr. Daniel Sharpe calling my attention to the occurrence of Caradoc sandstone at a spot on the eastern border of the Walsall Silurian district. Being in the district for a short time in March last, I visited the spot indicated by Mr. Sharpe, and found to my surprise a quarry I had previously overlooked. It is a very old quarry, much overgrown by bushes and brambles, and in a field which was, I believe, covered by standing corn when I surveyed the district in 1849. From these circumstances, although I had passed within a few yards of it, it escaped my notice.

On visiting it this year, I was accompanied by Mr. George Eglinton, the occupier of the ground, who was aware of the peculiar character of the sandstone, and who also guided me to another very remarkable little section, near Hay Head, which had escaped my previous observation from the same circumstance of being overgrown by bushes, which in the summer would render it invisible.

The first-named locality is a little south of the sixth milestone on the Birmingham and Walsall road, in the fourth field S.S.E. of Shustoke Lodge. The old quarry is just below the summit of a

small rising ground, which forms a distinct little ridge about 80 yards across and 200 or 300 long, sloping down gently on every side. The rock is a pale yellow or brown sandstone, in some places nearly white and purely quartzose, in others very ferruginous, marked by concentric rings of a dark brown colour, and containing little ochrey nodules. It had also small bands of highly calcareous grit, and some of the blocks had a central nucleus of white arenaceous limestone. It was traversed by joints in all directions, splitting it into very sharply angular fragments; and I was not able to detect the bedding with sufficient accuracy to state its dip, owing to the smallness of the portion we were able to expose. Some parts of it were crowded with fossils, which Mr. Salter has kindly determined for me.

Fossils of the Upper Caradoc Sandstone collected near Shustoke Lodge, Great Barr, Walsall, April 1853.

Trilobites.	
Encrinurus punctatus	4
Phacops caudatus	1
—— Stokesii	1
—— truncato-caudatus ?	1
Brachiopods.	
Chonetes lata (probably)	1
Strophomena compressa	2
Atrypa reticularis	6
Rhynchonella—two plaited species.	8
Rhynchonella—small smooth species	50
—— Wilsoni	20
Pentamerus liratus ?	2
——	
Pterinea	1
Crinoidea.	
Periechocrinus moniliformis	30
Bryozoa.	
Fenestella (with close meshes)	1

[J. W. S.]

Fragments of the sandstone were strewed over the upper part of the field near the quarry, but over the lower portion, as well as in the ditches on the other sides of the ridge, were found many fragments of limestone slabs with the ordinary Wenlock fossils in great abundance. I believe, therefore, that the Hay Head or Barr limestone (which is probably the same as the Woolhope) will be found to wrap round the foot of the ridge. The Permian boundary here makes a slight bend round the eastern side of the sandstone ridge.

The second locality is a little gully, just east of the house called Daffodilly, at Hay Head. The bank is never more than 3 feet in height, and it is much broken; we found in it, however, within the space of 30 or 40 yards, Wenlock shale and slabs of limestone on the west, just by the old quarries of the Hay Head limestone. East of this, for about 10 yards, there was coal-measure shale, with a bed of good coal nearly 2 feet thick, apparently in a nearly horizontal position; east of that again, for 5 or 6 yards, was a sandstone, exactly similar to that near Shustoke Lodge in lithological character, with similar calcareous portions, but, so far as we could determine, after an hour's hammering, destitute of fossils; and immediately east of that, dark red brown marls and shaly sandstone, belonging to the Permian rocks. In the next field to the east were the mounds of two old shafts in which coal-measures were said to have been reached at no great depth. At the Three Crowns Inn, 150 yards to the north, a two-foot coal had recently been found in sinking a well, dipping gently to the east. I believe these coal-measures to be

merely thin outlying portions of those to the westward, lying unconformably on the slightly inclined edges of the Silurian rocks, and resembling in position the thin coal-measures found on each side of the Lickey ridge near the Colmers. There are some circumstances in the structure of this portion of the district which would incline us to the belief that the edge of the Silurian and Coal-measure rocks is here rather an old cliff, or other margin of denudation, than a fault. They are, however, explicable also if we suppose the Silurian rocks to have been slightly undulating, and the fault that traversed them likewise wavy, so that in some places it cut through slight elevations of the Caradoc sandstone, and the lower measures (leaving portions of them, now exposed at the surface, on *the upcast side*), while in other places it cut through higher beds which now abut against the fault, having the top of the Caradoc sandstone a slight distance beneath them. The discovery of Caradoc sandstone in this district beneath the Wenlock shale, in its characteristic and unaltered condition,—that discovery being due to Mr. Sharpe,—is interesting both in itself, and as confirming, were confirmation necessary, Sir R. I. Murchison's identification of the quartz-rock of the Lickey Hill, as a metamorphosed Caradoc sandstone.

[*Note.*—The term "Caradoc sandstone" is used here in its old signification,—possibly "Wenlock grits" might be the more appropriate term for these beds.—J. B. J. July 14, 1853.]

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3. *On the* Silurian Rocks *of* Kirkcudbrightshire. By Robert Harkness, Esq., F.G.S., Professor of Geology and Mineralogy, Queen's College, Cork.

[Abstract.]

In the Stewartry of Kirkcudbright* the Lower Silurian Rocks, accompanied by igneous rocks, constitute the great mass of the country. From the intrusion of the syenites and porphyries these lower silurians are much changed both in lithological character and in inclination, being bent into several axial flexures (all apparently intimately connected and possibly contemporaneous†) by the syenitic eruptions of Criffel, Cairnsmuir, and Loch Doon, and by the porphyry of Tongueland. The silurian deposits are best seen on the coast. Here precipitous headlands form the margin of the Stewartry, and these afford information concerning these strata, which would otherwise be inaccessible; and here too deposits of a different age are met with. Commencing at the eastern side of the county, we have in

* In illustration of the observations made in this paper, Mr. Harkness has furnished a Map and Section. The former consists of two sheets (Nos. 54 and 55) of the Ordnance Survey Map, of the 6-inch scale, coloured geologically, and extends from Barlocco Bay to Borness Point. The latter is a coast-section from Netherlaw Point to Balmae Head, and thence to Cutters Pool, about two miles up the eastern side of Kirkcudbright Bay. The inclined and vertical beds of the cliffs, with some of the intrusive trap-dikes, are represented in detail, and the Section includes a hypothetical representation of the flexures of the strata, as deduced from the various inclinations which are seen exposed.

† See also Quart. Journ. Geol. Soc. vol. viii. p. 393.

the parishes of Irongray, Terregles, and Troqueer, new red sandstone; being the western extremity of that which occupies the southern portion of the Vale of the Nith*. At Kirkconnell, the most easterly portion of the syenitic district of Criffel is seen, and this is immedately succeeded in the south by silurian strata dipping 25° S.E. At Corbally, in the parish of New Abbey, the representatives of the carboniferous formation make their appearance, and then continue along the coast, round Southerness Point, to near the parish of Colvend, occupying a comparatively low tract of country. Near Southerness the beds consist of limestone which has been wrought; and they contain the characteristic fossils of the lower portion of the mountain limestone. In this formation, near Arbigland, a small seam of coal occurs, and the strata here have great analogy to those which in Dumfriesshire and Roxburghshire afford the limestone used for agricultural purposes, and which occupy a position between the coal-field of Cannobie and the silurians which lie northward. In the parish of Colvend the coast consists principally of porphyry and syenite, with altered silurian rock often much contorted. On this coast the representatives of the carboniferous beds are seen between Port Ling and Port a Warren, and are composed of grits containing fragments of the igneous rocks which occur to the northward. Westward from Port a Warren, altered silurians and igneous rocks are seen, forming lofty headlands which continue until the representatives of the carboniferous beds again make their appearance a little to the east of Glen Stocken. At the latter locality the igneous rocks and altered silurians are again well-exposed, and east from this spot the grits are wrought for millstones. A small patch of silurians is exposed in a small cove at Barcloy, and to the eastward the syenite is found, forming the headlands of Barcloy and Almorness and the shores of the estuary of the River Urr. These extend on the west side to Balcarry Bay, where the silurians again occur, dipping at a high angle southward; and these strata form the island of Hestan which lies on the south-west side of the Bay of the Urr. The silurians continue along the coast round Balcarry Point, which is a bold headland, and immediately west from this they are succeeded by the grit-beds already mentioned. These continue to form the coast, at Airds, Rascarrel, and Barlocco; and at Rascarrel search has been made in them for copper. Here they are intersected by a thick vein of pure quartz; and in some places fissured without containing any matter filling up the fissures†. At Barlocco the grit-beds abound in large angular fragments, which have been derived from the silurian rocks.

From Barlocco westward the same deposits are seen, varied at Orroland by beds of limestone, similar in nature and fossil contents to that which occurs at Southerness. These grits continue to Port

* See Quart. Journ. Geol. Soc. vol. vi. p. 389 *et seq.*

† Some of the portions of rocks fissured present a very singular appearance. These, where the strata are horizontal, have their margins surrounded by a raised beading which seems to have resulted from water having penetrated the fissures and furnished siliceous matter, which entering into the walls hardened them and rendered them less susceptible of the weathering influence of the sea and atmosphere.

Mary. A little to the east of this place the grits are traversed by veins of sulphate of barytes. At Port Mary the silurians again make their appearance, and in the course of the small burn are seen dipping S.S.E. at an angle of 55°.

Diagram illustrative of the relations of the Upper and Lower Silurian Rocks of Kirkcudbrightshire. The trap-dikes are omitted.

* Carboniferous grits. *a.* Shales and sandstones; *b.* Sandstones; *c.* Graptolite shale. *d.* Lower Silurian rocks.

Immediately west from Port Mary the grits reappear, and run along the coast to Abbey Burnfoot; where the silurians are seen, having a north inclination at Guthries Pool. Up the Netherlaw Glen, from whence the burn flows, the inclination of the silurians is the reverse of what occurs at Guthries Pool, being to the south at an angle of 50°.

From Abbey Burnfoot westward the grits again occur, and occupy the coast to Netherlaw. Here they consist of red-coloured beds containing rounded and angular fragments of quartz and silurian rock, and have a southerly dip, at an angle of 17°, which is the prevailing dip of the carboniferous equivalents in this county.

At Netherlaw Point commence the series of silurian rocks which it is the object of this paper more particularly to notice. Some of these have been more or less fully described in a former paper*; but the relation they bear to the deposits constituting the great mass of the silurians of the South of Scotland has not yet been shown. Near the summit of the headland the silurian strata are covered by the carboniferous grits, but the point of contact between the two formations is not seen; they consist of 1. (uppermost) Shale and sandstone; 2. Sandstone; and 3. Graptolite Shale.

No. 1 comprise, in the *Upper part*,—light-grey shales (with calcareous nodules), alternating with light-grey sandstones, in beds rarely exceeding a foot in thickness. The under-surface of the sandstone is ripple-marked† (as seen at Netherlaw and Gipsey Points). This sandstone at Gipsey Point is much coarser than that at Netherlaw Point, of which it is a repetition, and it contains fragments of quartz and jasper, and a fragment also of syenite was found in it by the author, similar to the syenite

* See Quart. Journ. Geol. Soc. vol. vii. p. 54.

† These ripple-marks are not of the waved form which usually occurs on ripple-marked sandstone, but consist of irregular hollows and sinuous elevations, often terminating abruptly. A similar ripple-mark occurs on the under-surface of the red sandstones near Annan, Dumfriesshire, where they lie on beds of clay. See Quart. Journ. Geol. Soc. vol. vi. p. 397.

of Kirkcudbrightshire. These beds appear to have been deposited in a shallow sea; no fossils have yet been found in them.

In the *Lower part*, similar shales and thin flaggy sandstones.

The calcareous nodules in the upper shale have afforded at Gipsey Head the fossils already noticed in the Society's Journal *; and in one of the shale beds with nodules, at the N.W. side of Big Raeberry, numerous specimens of *Orthocerata*, in a more or less fragmentary condition, occur, together with broken shells of *Terebratula* and *Orthis*, and Crinoidal rings. These remains generally lie in close proximity to thin wavy courses of sandy particles which run through the shale, and appear to have been left by the silurian sea in the hollows of the rippled mud. The shell fragments have a bleached aspect, and altogether the character of this deposit has reference to sea-beach conditions. (See Ann. Nat. Hist. 2 Ser. vol. iii. p. 156.)

No. 2 consists of greywacke sandstone; the lower part thick-bedded. No fossils were found in it.

No. 3 consists of indurated black shale with Graptolites. *Graptolithus priodon*, Bronn, and *G. Flemingii*, Salter, are found at Mullock Bay; and *Orthocerata* with *Graptolites*, at Brandy Craig.

A little south of Long Robin is the most northerly point at which the author met with the graptolitic shale.

Along the coast from Netherlaw Point to Balmae Head (Gipsey Point), these rocks occur in highly inclined and vertical beds, and appear to form two or more synclinal troughs, which have a nearly east and west direction. From Balmae Head northward, for about two miles along the east side of Kirkcudbright Bay, the coast-section traverses six or more synclinal troughs, parallel to the former, consisting of the greywacke sandstone and graptolite shale, which underlie the shales and sandstones of No. 1.

Throughout all this line of coast the silurians are traversed by vertical dikes of porphyries and amygdaloidal traps, the general direction of which is about N.E. and S.W. One porphyry dike, however, occurring at intervals on the face of the cliff along the east side of the Bay, appears to have had a sinuous N. and S. direction.

The origin of the flexures into which all the strata have been thrown is in part the intrusion of the dikes of porphyry, &c., intersecting the Silurian rocks of this district†. There must, however, have been some other cause, combined with these dikes, which is not apparent, and which acted laterally, in order that a succession of flexures, such as are here noticed, should have been produced.

Of the thickness of these rocks, owing to the contortions of the beds, even an approximation can scarcely be arrived at.

This series of deposits constitute the Upper Silurians,—as they occur between Netherlaw Point, at the western extremity of the Parish of Rerwick, and the Cutters Pool, in the Estuary of the River Dee. These, however, are not the sole representatives of this portion of the silurian formation in this neighbourhood. The Island of Little Ross, on the western side of the entrance into Kirkcudbright

* Vol. iv. p. 206; and vol. vii. p. 54.

† See also Quart. Journ. Geol. Soc. vol. vii. p. 56. fig. 2.

Bay, is composed of strata analogous to those of the main land on the eastern side of the Bay, as, indeed, the strike of the latter would have led us to expect; these have already been described by Mr. Thomas Stevenson*. Here the black shales with Graptolites occur, with greywacke, and trap-dikes. On the west side of the Bay similar strata are found in the Big Ross, on the N.E. side, at Manor Point, dipping S.S.E. at 60°. North of this, on the north side of Balmangan Bay, the dip is in the same direction, at an angle of 55°, and here beds having a different aspect appear; and, on following the west side of Kirkcudbright Bay northward, these rocks form the coast to near the town of Kirkcudbright. They bear a great resemblance to the general mass of rocks composing the lower silurians of the South of Scotland, and differ essentially in character from those described in this paper. In some localities they are conglomeratic, and they have a more regular S.E. inclination than any deposits lying on the other side of the Bay. These lower silurians are not altogether devoid of flexures, but these are local and of small extent.

The prevailing inclination of the lower silurians of the South of Scotland is towards the N.N.W. at a high angle; but the S.E. and S.S.E. inclination of these rocks in the Parish of Borgue is the result of the intrusion of the Tongueland porphyry. This S.E. dip, prevailing along this coast to the Headland of the Big Ross, is regarded by Mr. Harkness as having existed previously to the deposition of the upper silurians (as these are developed at Balmae); and he observes, that "the circumstance, that these lower silurians have not been acted upon by the forces to which the Balmae beds owe their contortions, tends to show a difference in the age and position of these two series of strata. There is another circumstance, he adds, which indicates that the prevailing inclination obtained prior to the deposition of the Balmae beds. This is the occurrence of a rounded fragment of syenite amongst the shales in which the nodules containing fossils are found; and, as this syenite is identical in its nature with those forming the axes of the lower silurians, it had in all probability been derived from some of these, and thus it supports the inference that the S.E. or S.S.E. dip which resulted from the intrusion of this syenite must have prevailed anterior to the deposition of the shales in which this fragment of the igneous rock is found. On the whole, if we take the evidence of the fossils at Balmae,—the difference in the lithological character of the beds here, and of those which lie to the northward,—the extent of flexure which characterizes the former, and the occurrence in them of igneous dikes of a distinct nature from the intrusions which have elevated the latter,—I think there is sufficient proof of the later deposition and contortion of the Balmae beds. Where we have a series of beds elevated at a high angle, and sometimes nearly approaching the perpendicular, succeeded by contorted beds, which have been much-denuded, and which also assume a perpendicular position, it is difficult to determine the exact point where the two formations come in contact; but, judging from the general occurrence of the more uniform S.S.E. dip on the north side

* Edinb. New Phil. Journ. vol. xxxv. p. 83.

of the Big Ross, and the appearance of the perpendicular beds, which strike from the Little Ross where the Balmae beds are seen at its southern extremity, I consider this headland (Big Ross) as being formed in part of lower and in part of upper silurian. And I am led to the conclusion that these lower silurians offered resistance to the lateral pressure which acted upon the upper silurians, and that from this resistance the flexures which now abound amongst these latter, as they occur on the coast of the Parish of Kirkcudbright, are in a great measure owing."

There is great difficulty in tracing out the connection between the upper silurian beds, as these are developed at Balmae, on the east side of Kirkcudbright Bay, and the lower silurians which lie on the coast due north of these beds. Here the strata are only seen to a small extent for about a mile northwards from the spot where they disappear beyond the Bathing-House Bay. And from this point, which is near the Black Murry, to St. Mary's Isle, there is great confusion in the direction both of the dip and strike; and to such an extent does this prevail, that it makes the strata here exposed of little value so far as regards the connection between the two formations. Beyond this locality the silurians are in contact with a portion of the porphyry which belongs to the mass occupying a considerable area in the adjoining Parish of Tongueland; so that on this side the Bay there is little evidence of the relative positions of the upper and lower silurians.

The beds which in the Parish of Kirkcudbright lie to the north of these sandstones and conglomerates are not well exposed, except in the course of the Dee. Near the adjoining Parish of Tongueland they are so much metamorphosed by the porphyry of this latter locality, that they have lost their original character. At Coal Heugh, however, near Barcaple in this parish, the anthracites make their appearance* and connect these deposits with the lowest beds of the silurians.

"We have, therefore, in this portion of the Stewartry," Mr. Harkness observes, "deposits which represent the Llandeilo flags,—conglomerates and sandstones which may be regarded as the representatives of the Caradoc sandstone,—and a higher series of beds (Balmae beds) which are equivalent to the lower portion of the upper silurians, and which have hitherto been recognized in Scotland only on the western portion of the Parish of Rerwick, the coast of the Parish of Kirkcudbright, and on the eastern extremity of the Parish of Borgue."

The lower silurian thick-bedded sandstone and conglomerates of the west side of the Bay form the coast westward from Fallbogue Bay to the Mull of Ross, keeping the S.S.E. inclination. At the Mull Point they are curved, and these flexures are repeated along the sides of Bridgehouse Bay; but the prevailing dip is S.S.E. The same beds continue along the coast from Bridgehouse Bay to Borness Point, with similar flexures. No fossil remains have hitherto been procured from this series.

* See Quart. Journ. Geol. Soc. vol. vii. p. 50.

4. *On* Pseudomorphous Crystals *of* Chloride *of* Sodium. By G. Wareing Ormerod, M.A., F.G.S.

In a paper read before this Society, on 1st December 1852, by Mr. Strickland, on Pseudomorphous Crystals of Chloride of Sodium in Keuper Sandstone *, no reference is made to prior observations on the same point. In my paper "On the Principal Geological Features of the Salt-field of Cheshire †" it is stated that "the Waterstone beds (a subdivision of the Keuper) at Holmes Chapel have the same peculiar crystal as those at Lymm, Preston on the Hill, and elsewhere;" and in a note it is added, "At this place the crystals are of silicate of protoxide of iron. This seeming crystal is probably caused by the component matter taking the places of scattered crystals of Chloride of Sodium, the form of which both in Cheshire and at Slime Road in Gloucestershire they have taken, exhibiting, if so, the lowest traces of the salt." To Mr. Crace Calvert (Honorary Professor of Chemistry at the Royal Manchester Institution) I was indebted for the examination of this specimen, and to him any credit for the discovery, as far as relates to Cheshire, is due, he having, on my showing him the specimens, stated his opinion that the crystals were Pseudomorphic Chloride of Sodium. I had omitted to ask his permission to allow me to mention his name when my paper was read, and it was therefore not then given. This paper was read before the Geological Society 8th March 1848, when specimens were exhibited and a discussion took place, when Professor Buckland mentioned many localities in which he had observed this pseudomorph, for which he had not hitherto been able to account.

In July 1850 the Government Reports of the Natural History of the State of New York were sent over as a donation to the Free Library and Museum of the Borough of Salford, and shortly afterwards, on examining the geological division of that work, I found that the same peculiar crystal had been observed in the district lying to the south of Lake Ontario. In Part 3, pages 102 and 103, Mr. Lardner Vanuxem notices them thus: "Hopper-shaped cavities, Onondaga Salt Group. These forms and cavities are of great importance, for they were produced by common salt, no other common soluble mineral presenting similar ones. They are found in the gypseous shale or marl in its more solid and slaty parts." A drawing is given of specimens (from Bull's Quarry, Town of Lenox, Madison County) in which the pseudomorphs resemble those found in Cheshire and Gloucestershire which have come under my notice.

In Part 4, page 127, Mr. James Hall mentions that similar crystals were found in Wayne and Monroe Counties, but that he had rarely observed them in Genesee or Erie Counties, the most perfect which he had seen being at Garbutt's Mill on Allen's Creek. Part 3 was published in 1842, and Part 4 in 1843.

In making these observations, I must not be understood as in any way attempting to take from Mr. Strickland the credit of a dis-

* Quart. Journ. Geol. Soc. vol. ix. p. 5.

† Quart. Journ. Geol. Soc. vol. iv. p. 273.

covery: before he directed special notice to it, the matter was only incidentally mentioned, and he was doubtless quite as much unaware that it had been noticed before, as Professor Calvert or myself were; my object has been to direct attention to this matter as showing the great extent of country in which this singular crystal is found. The observations of Mr. Strickland and myself show that it is found in the Keuper Sandstone through a considerable portion of Gloucestershire, and I have noticed its frequent occurrence in Cheshire; Professor Phillips has found it in Worcestershire, and Dr. Percy in Nottinghamshire. The observations of Messrs. Vanuxem and Hall show the existence of a similar pseudomorph in North America, in the district to the south of Lake Ontario, extending from Erie County through Genesee, Monroe, and Wayne to Madison County. There, however, these crystals are found in the Onondaga Salt Group, belonging to the Upper Silurian Division.

Note on the occurrence of similar Crystals. By W. W. Smyth, Esq., F.G.S.

The presence of pseudomorphous crystals, similar to the above-mentioned, in several divisions of the Trias, has long attracted notice on the Continent, and has been detected at very numerous points scattered over a large proportion of Northern Germany. In Leonhard and Bronn's Journal for 1847, Gutberlet has devoted an elaborate paper to the description and geological discussion of those more particularly which occur in beds of variegated marls between the Bunter Sandstein and the Muschelkalk. They have also been described by Dr. Dunker as occurring in the Wealden of Germany; by Braun, in the marl-slate of the Zechstein near Frankenberg; and by others, in the tertiaries of Austria and of the South of France.

In all these different localities the "hopper-shaped" crystals (or cubes with hopper-shaped impressions) are the most frequent, and are the same forms of salt which are produced by gradual evaporation, whether in salt-pans or on a sea-shore. The materials of which these pseudomorphs are constituted vary with the composition of the adjacent rocks, and are, in different localities, marly limestone, dolomitic marl, gypsum, quartz (more or less pure), sandstones of many kinds, mica, and brown spar, the last two often disposed only round the edges. In the first-mentioned paper, and in some by Hausmann and Nöggerath on the same subject, will be found much valuable and suggestive matter connected with both the chemical and geological aspect of the subject.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

On the SALT RANGE *of the* PUNJAUB. By DR. ANDREW FLEMING, E.I.C. Assist. Surg. 4th Punjaub Cavalry. [*Abstract from Letters* addressed to* Sir R. I. MURCHISON, F.R.S., F.G.S.]

[Read April 7, 1852†.]

Introductory Observations by Sir R. I. Murchison.—The conquest of the Upper Punjaub has opened out to us the means of becoming better acquainted with the true geological succession of the sedimentary strata of the peninsula of Hindostan. Already through the writings of Major Vicary, who acquired the greater part of his knowledge as a soldier employed in active warfare, we were instructed as to the vast extent of those nummulitic limestones which I have classed as Eocene or older tertiary‡, as well as of the younger tertiary and bone deposits which overlie them§. Major Grant and others have described secondary rocks chiefly of the age of the Oxford oolite; and cretaceous deposits occur at Pondicherry; but the author of the letters I now communicate to the Society has proved the

* The 1st Letter, dated, Camp, Murree Hill Station, *viâ* Rawal Pindee, Punjaub, May 29, 1851; the 2nd, Kutta, Salt Range, 30 miles W. of Pind Dadun Khan, January 16, 1852; and the 3rd Letter (received, together with a collection of fossils and rock-specimens, since the first two letters were read before the Society), dated, Camp, Pind Dadun Khan, March 30, 1852).

† For the other papers read at this evening's Meeting, see Quart. Journ. Geol. Soc. vol. viii. p. 225.

‡ See Quart. Journ. Geol. Soc. vol. v. p. 303. The work by M. d'Archiac on the Nummulitic Formation of India, just published, gives a full description of the various forms of Indian Nummulites and a notice of their associated shells, &c.

§ See also Major Vicary's paper on the Subathoo Range, *supra*, p. 70.

existence of true palæozoic rocks* in Hindostan proper to the South of the Himalaya mountains; and, in doing so, indicates, that great masses of the Salt of the Punjaub occur in deposits of the age of our Old Red Sandstone (Devonian).

In his first letter, dated from the Murree Hill, 29th May, 1851, the author mistrusted the evidence on this last point, although it was clearly placed before him; being then unaware that salt masses occurred in any formations of higher antiquity than the 'New Red' or 'Trias.' In reply I explained to him, that in this respect the salt of the Punjaub occupied precisely the same position as the Russian salt of Livonia, and that in other countries that mineral was found associated with formations of nearly every age from the oldest to the youngest. [The second letter is in reply to my explanation.]

With regard to the palæozoic limestone described in Dr. A. Fleming's Letters (the No. 5 of his section), I have to remind the Society that a series of its fossils were sent home to his father the Rev. Dr. Fleming in 1848, and exhibited at the Meeting of the British Association at Edinburgh. The following species were subsequently identified by M. de Verneuil and Mr. Davidson:—

Productus Cora, *D'Orb*, a species known in Peru and Spitzbergen, as well as very generally on the continent of Europe, even southwards to the Sierra Morena, where it was detected by M. de Verneuil.

Productus costatus, *Sow.*
Productus Flemingii, *Sow.* } Well-known Carboniferous forms.
Orthis crenistria? *Phill.*

Terebratula Royssii, *L'Eveillé*, of America and Belgium.

Terebratula crispata? *Sow.*

And several new species of *Terebratula*, &c.

In an introductory notice to Major Vicary's paper on the Geology of the Upper Punjaub, read before the Society in December 1850†, I briefly referred to Dr. A. Fleming's discovery of these fossils, in connection with the researches by Dr. Falconer and Major Vicary on the palæozoic rocks of Northern India.

The second letter of the author, dated 16th January, 1852, from Kutta, in the Salt Range, sustains the chief views pointed out in the first letter with some explanations. The principal feature of interest which is added is the expression of the author's belief, drawn from physical phænomena, that the chief saliferous masses have been produced by eruptive agencies. This opinion must be the more entitled to our consideration, as it is manifestly the result of observation in the field, and not derived from a desire to follow the theories of any author; Dr. A. Fleming being unaware (removed as he is from all

* A letter to me from Professor Oldham announces that the supposed Old Red Sandstone and Carboniferous rocks of Chirra Poonjee to the N.E. of Calcutta, described as such by Dr. M'Clelland, have proved to be older Tertiary and nummulitic strata; all the coal of the region between Assam and the Plains of Sylhet being subordinate to them.

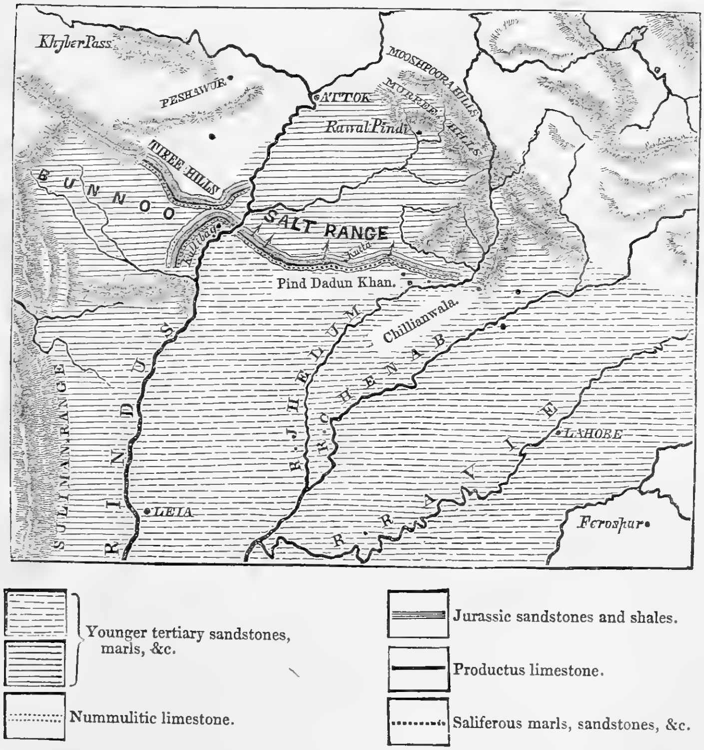
† See Quart. Journ. Geol. Soc. vol. vii. p. 39.

scientific works) that some distinguished geologists have entertained a similar opinion.

In order to do some justice to the able researches of my young friend, I have sketched out a rough geological map of the Upper Punjaub, adding a few names to those ridges which, traversed by the Jelum and the Indus, have not yet found their way into any published map.

Fig. 1.—*Sketch Map of the Salt Range and a part of the Punjaub.*

(Scale 80 miles to 1 inch.)



In calling attention to this map, I would now simply remark that the Salt Range, varying from 2000 to 5000 feet above the sea, may be considered as the first great step in ascending from the plains of the Lower Punjaub. The Murree and Mooshpoora Hills form the second and third ledges, the one rising to about 7000, and the other to near 10,000 feet. Further north, and parallel to them, is the major axis of the great Valley of Cashmeer, and finally the last grand parallel—the mighty Himalaya.

The upcast of the palæozoic formations in the lowest or southernmost of these ridges constitutes the chief interest of this communication, and leads us to hope how, with an extension of surveys, other palæozoic zones may be found besides those in the higher ranges in which Capt. Strachey has already developed true Silurian rocks*. In the meantime, we find, through the labours of independent observers, that, however dismembered and separated, Silurian, Devonian, and Carboniferous rocks of Europe and America exhibit their representatives in the Himalaya Mountains, and thence extending into Hindostan.

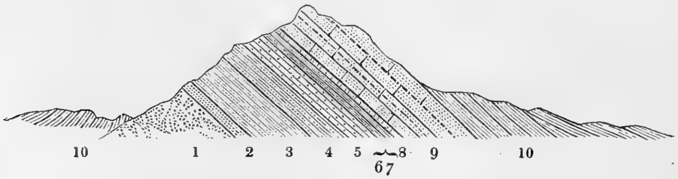
Another great geological feature is brought out by these researches, in the evidence that the palæozoic rocks of the Salt Range have been upheaved posterior to the well-known tertiary bone-beds of Northern India. Hence there is every reason to believe that in the East as well as in Europe, some of the mightiest dislocations, like those of the Alps, Apennines, and Pyrenees, have taken place after the formation of deposits charged with the spoils of the largest quadrupeds.

[R. I. M.]

The Salt Range, in the Northern Punjaub, consists of a series of stratified rocks, having a general E. and W. strike, and dipping to the North at angles varying from 35° to 50°. The direction, however, of the dip, as must be the case in all mountain chains, is irregular. Although the strata forming the Range present such a high general inclination, yet no intrusive rock has yet been met with by the author of this communication, who has been engaged under Government for some years in carrying on researches, chiefly on the south side of the Range, with a view to develope the mineral resources of the Punjaub.

The subjoined diagram, Fig. 2, exhibits the general structure of the Salt Range†.

Fig. 2.—*Diagram showing the general section N. & S. across the Salt Range, Northern Punjaub.*



The figures in the diagram have reference to the following list of the strata composing the range.

* See Quart. Journ. Geol. Soc. vol. vii. p. 292, &c.

† For Reports (geological, mineralogical, &c.) on the Salt Range, by Dr. A. Fleming, see Calcutta Journal of the Asiatic Society of Bengal, 1848–49, vol. xvii. and xviii.

The principal strata, in ascending order, are—

1. Gypseous red marl with rock-salt.
2. Red sandstone, with clays, grits, and conglomerates.
3. Bluish shales and greenish micaceous sandstone. Indistinct vegetable impressions. 400 feet thick.
4. Variegated sandstone and variegated shales. Cupriferous nodules. 150 to 200 feet thick.
5. Limestone, with chert. *Productus*, &c. 200 to 300 feet thick.
6. Sandstone, bituminous and pyritous shales and limestones. Lignite. Ferns.
7. Bituminous shales, blue clays with septaria, and lignite.
8. White limestone. *Alveolina*, &c.
9. Nummulitic limestone, with flint. *Nummulites*, &c. 300 to 400 feet thick.
10. Soft sandstone, marls, and red clays. Mammalian bones.

The following Table is compiled from Dr. A. Fleming's collection of organic remains, sent to England since his first two letters were read before the Society, and the lists of fossils in his letters.

Belonging to No. 5 *of the Section:—*

Productus	Limestone,	Moosakhail,	Athyris Royssii, *L'Ev.*	
"	"	"	Terebratulæ (Rhynchonella, &c.).	
"	"	"	Echinodermata.	
"	"	?	Spirifer, n. sp.	
"	"	?	Strophomena, n. sp.	
"	"	?	Retepora fastuosa ?, *De Kon.*	
"	"	?	Lithodendron (Subbee ?).	
"	"	Subbee,	Encrinites.	
"	"	"	Orthoceratite ?	
"	"	Chederoo,	Fish bone and teeth (Helodus, Orodus, &c.) Upper beds of the lower productus-limestone.	
"	"	"	Ceratites.	
"	"	"	Bellerophon hiulcus, *Sow.* (Coarse calcareous shale.)	
"	"	"	Spirifer, allied to Sp. lineatus, *Sow.*	
"	"	Vurcha,	Fish-bone. Upper bed of lower productus-limestone.	
"	"	"	Nautilus, like N. tuberculatus, *Sow.*	
"	"	"	Ceratites, 2 species.	Crystalline limestone.
"	"	"	Small Pecten, &c.	
"	"	"	Bellerophon.	Coarse limestone.
"	"	"	Ceratites.	
"	"	"	Cardinia.	
"	"	"	Productus.	
"	"	"	Strophomena, like S. crenistria.	
"	"	"	Dentalium* ingens, *De Kon.*	
"	"	Kafir Kote,	Ceratites.	
"	"	"	Productus Cora, *D'Orb.*	
"	"	"	——— Humboldtii, *D'Orb.*	
"	"	"	——— costatus, *Sow.*	
"	"	"	Spirifer ?	
"	"	"	Encrinites.	

* In the author's earlier notes on the Salt Range, the obscure casts and fragments of this fossil were referred to provisionally as Belemnites.

Encrinital white limestone,	Nulle,	Dentalium ingens, *De Kon.*
,, ,,	,,	Productus.
,, ,,	,,	Encrinites.
Ceratite flag limestone,	?	Orthoceratite and Ceratites.

Belonging to Nos. 6 *and* 7 *of the Section* (*Jurassic* ?) : —

Sandy shales,	Moosakhail,	Pecopteris. Lignite (coniferous wood).
,,	Kalabagh,	Lignite (coniferous wood ?).
Green sandstone,	Kalabagh,	Belemnites*, 2 or 3 species
,,	,,	Ammonites, allied to A. Herveyi, *Sow.*
,,	,,	Gryphæa or Exogyra.
,,	Kothee,	Astarte.
Limestone,	Chulalee Pass, W. of Indus.	Pecten and Terebratula (Rhynchonella), like T. tetraëdra, *Sow.*

Eocene Tertiary :—

No. 8. Alveolina limestone,	Moosakhail,	Shark teeth.
,,	,,	Neritina ?
,,	,,	Echinodermata.
,,	,,	Alveolina.
No. 9. Nummulite limestone†,	,,	Conus.
,,	,,	Terebellum.
,,	,,	Cerithium.
,,	,,	Neritina ?
,,	,,	Pecten.
,,	,,	Echinodermata.
,,	,,	Nummulites.

All the beds, from the red sandstone to the uppermost sandstones, appear to be conformable, but there is considerable confusion and disturbance accompanying the salt-marl. The conformability of the whole series is much more apparent in the eastern part of the Range where the salt-marl is less developed.

The lowest observable rock in the Salt Range is a vast deposit of gypsum, gypseous red marl, and rock-salt‡ (No. 1), which may be described as a red gypseous clay containing broken-up stratified masses of gypsum and salt. Above this is a thick deposit of red sandstone (No. 2), its lower beds being schistose, and, near the salt, alternating with dark red clays. The sandstone frequently contains bands of grit and conglomerate, chiefly of small boulders of metamorphic rocks. It is of little thickness towards the Indus, but it increases in force to the eastward, and in some places it is not less than 400 feet thick. Above the sandstone is a small series of coarse, bluish, arenaceous shales and micaceous sandstone (No. 3), tinged green with chlorite, and often presenting carbonaceous, but

* The Belemnites and Ammonites of which Dr. A. Fleming has sent specimens are "Oxfordian" forms; *i. e.* of the same formation of Oolite or Jura as is known in Russia, Cutch, and the Himalaya.

† See also M. D'Archiac's Descrip. An. foss. du Groupe Num. de l'Inde, p. 173.

‡ At some places masses of red sandstone and conglomerate appear at the foot of the southern flank of the Salt Range, but these are not inferior to the salt and gypsum (as at first sight they sometimes appear to be, and indeed as they were described to be in Dr. Fleming's first letter and in his Reports referred to above), but are deranged beds and out of their place.

most indistinct, vegetable impressions. Above this, and often in alternating beds of various thickness, is a light-coloured calcareous sandstone, weathering to a fawn-colour. The thickness of Nos. 2 and 3 taken together may be on an average about 400 feet. Above this occurs a variegated dark red sandstone, alternating with red, green, and purple shales, from 150 to 200 feet thick (No. 4). Concretionary nodules of copper-glance have been found in these shales, but no vein of ore has yet been discovered, and the concretionary nodules occur in greatest quantity in the clay formed from the disintegration of the shales. Resting on the shales (at Moosakhail, south side of the Salt Range, twenty-eight miles E. of Kalabagh) is a very hard splintery limestone (No. 5), containing irregular masses of hornstone or flint. Its lower part is indistinctly stratified and is much fissured; but the upper part of the deposit is more distinctly stratified. This limestone varies from a dirty white semicrystalline appearance to a steel-grey colour, and some of the beds are black and argillaceous. It has frequently an oolitic structure; it is generally fœtid on being bruised; and the specimens examined afforded no magnesia. At Moosakhail this rock is 200 or 300 feet thick. *Producti, Spiriferi, Terebratulæ, Echinodermata* (fragments of a large *Cidaris*?), Corals, &c., abound*. Encrinites are scarce in this locality, but some fifteen miles further east they are abundant and large. This palæozoic limestone, resembling in its fossils the Carboniferous limestone of Europe, has little of the appearance of the regular Mountain-limestone of North Britain (of Fifeshire for example); and in the shales and sandstones above and below it nothing like *Sigillariæ* and other Coal-plants have been met with. The Productus-limestone first appears in the Salt Range about thirty miles west of Pind Dadun Khan, gradually increasing in thickness to the westward, whilst the beds below it diminish and become less distinct. Above this fossiliferous limestone is a series of soft yellowish or brown sandstone, generally calcareous, bituminous shales, loaded with pyrites, and argillaceous thin-bedded limestones (No. 6). Flat masses of lignite (coniferous wood) occur in the sandstones and shales, and in a soft argillaceous sandstone Dr. A. Fleming obtained a Fern. The lignite in many places is converted into coke by the heat evolved during the spontaneous decomposition of the iron-pyrites in the shales. From these shales chalybeate and sulphureous springs issue, many of the latter being tepid. One of these indicated a temperature of 96° Fahr., that of the air being 69°. Its water gave a dense black precipitate with a solution of acetate of lead; and it deposited on the rocks over which it flowed a crust of sulphur. The author observes that some few fossil shells occur in series No. 6, and that he considers it probable that it is, for perhaps the greater part, of

* In 1841 Dr. W. Jameson visited the Salt Range and Kalabagh, and an account of his geological investigations appears in the Journal of the Asiatic Society of Bengal, N. S. vol. xii. p. 204, where it will be seen that Dr. Jameson also observed the occurrence of *Productus* and *Spirifer* in limestone, which, however, he considered to lie *below* the Rock-salt.

freshwater or estuarine origin. The upper argillaceous limestones pass by insensible degrees into alternating strata of bituminous shales, blue clays with septaria, and seams of lignite (No. 7). The lignite seams are of irregular thickness, in some places being 5 feet thick, while 100 yards distant on either side they degenerate into mere films among bituminous shales. Although the lignite generally presents the characters of brown coal, it is in many places highly bituminous and has the aspect of ancient coal.

Superior to the lignite is a white concretionary limestone (No. 8), which has frequently an oolitic structure. Its lower strata are often as white as chalk, and have the surface covered by a magnesian efflorescence. This limestone abounds in many places with spherical *Alveolinæ*, and in its softer parts the author has obtained two Shark-teeth, three or four Echinoderms, a *Neritina*?, and several other marine shells. The concretionary limestone becomes in its upper part more and more compact, and passes into a splintery limestone (No. 9), of a dirty white colour, with layers of black flint, and abounding in *Nummulites*, in some places being entirely composed of these organisms. This is the highest rock of the Salt Range*, the top of which on an average is about 2000 feet above the sea-level, and about 1500 feet above the plain at Pind Dadun Khan. The limestone on its weathered surfaces has a white chalky appearance in the distance, and forms precipices, on the south side of the Salt Range, in some places 300 or 400 feet high. It abounds with *Nummulites* and marine shells, viz. *Conus, Terebellum, Cerithium, Neritina*?, &c. Two or three species of Echinoderms also are found. The nummulitic limestone forms the northern side of the Salt Range, to near its base, where on it are seen reposing a series of more recent incoherent calcareous sandstones, marls, and red clays (No. 10), which in the author's Report to Government in June 1848, he referred to as being younger than the nummulite-limestone and of the tertiary age, and described as flanking the Salt Range and dipping under the table-land between the Salt Range and Hayara (north of the Peshawur Road, between Rotas and Attock), and bounded to the west by the Indus. These sandstones are the same as Major Vicary described in his paper published after the battle of Goojerat in 1849†. The strata forming the Salt Range *proper* appear to have been upheaved subsequently to the deposition of these younger tertiary sands, &c., as along the north side of the Salt Range they lie conformably on the nummulitic limestone, and are seen encircling the base of Mount Teela, near Jelum (the most easterly point of the Salt Range), and again, in nearly perpendicular strata, resting on the up-tilted strata forming the scarped southern side of the Salt Range at Jelalpoor, the older rocks having been evidently forced up through them. From thence they stretch across the Jelum in nearly horizontal strata, and form

* One of its highest ridges, Mount Sihesur, is by barometric measurement 5183 feet above the sea.

† See Quart. Journ. Geol. Soc. vol. vii. p. 38 *et seq.*

the Pubbee Hills on which the Seikh army encamped after the battle of Chillianwala. Dr. A. Fleming does not agree with Major Vicary in regarding the Pind Dadun Khan salt as belonging to these tertiary sands, &c.; though he thinks it probable that the Trans-Indus salt is found in some similar strata. Indeed, the author feels assured that the salt-deposits of the Punjaub Salt Range* have nothing whatever to do with the tertiary strata between Rotas and the Indus, described by Major Vicary, and in which Major Vicary found abundance of fossil bones. The quantity of calcareous tufa spread in irregular deposits over the surface of the low hills formed of these tertiary sands is very remarkable. Dr. A. Fleming has not found in them any fossil shells, but only the midrib of the leaf of a Palm, and bits of lignite, probably the remains of some coniferous tree.

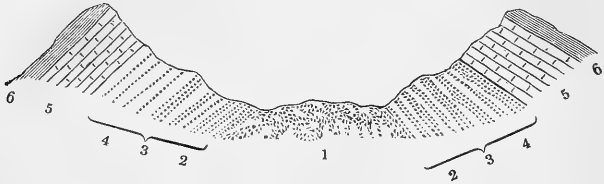
These tertiaries Dr. A. Fleming considers to be probably identical with the ossiferous beds of the Siwaliks, as they abound with fragmentary mammalian bones, which are chiefly confined to argillaceous grits. The author obtained a very large bone in a similar grit in sandstones which flank the Peer Punjal Range, fully 5000 feet above the sea.

The thickness of these younger tertiaries is very great, as is their extent likewise. They form a continuous sheet from Jelum up to Rawal Pindee, north of the Salt Range, and from Rawal Pindee up to Ooree on the Cashmeer River, where the author has seen them in connection with a highly quartzose mica-slate, which forms the central portion of the Peer Punjal. In a westerly direction they extend up to Cabul and all along the Indus below Kalabagh.

With regard to the probable origin of the Salt-marl, the author says,—"I am inclined to consider the saliferous rocks in the Salt Range of the Punjaub as being of an eruptive character—1. Because it presents no traces, or at most such as are very imperfect, of stratification. 2. Because it contains angular masses of other rocks of the Salt Range. 3. Because the gypsum and salt are for the most part found in large and small masses at irregular depths in the marl, being evidently portions of what originally has been a regular bed. 4. The gypsum is in some cases reduced to a white powdery rock, as if it were burned, and in and on the surface of the marl are formed fragments of a trappean rock, sometimes containing nests of talc, which I believe to be altered sandstone or clay. This trappean rock I have found nowhere in a dyke or bed, only in fragments in the marl, or in small detached lumps on its surface. 5. The red sandstone near the salt-marl is very much rent and broken, and where the salt-marl crops out there is a most extraordinary disturbance in the strata superior to it. It very often appears in valleys, filling these up, in a manner, while the strata dip from either side, thus (see fig. 3):

* Now yielding (May 1851) government 14 lacs of rupees (£140,000) annually.

Fig. 3.—*Diagram showing the anticlinal arrangement of the Salt-rocks and the Strata lying above them.*



1. Salt-marl.
2, 3 & 4. Shales and sandstones.
5. Productus-limestone.
6. Sandstones and shales.

"The salt-rock seems to me, observes the author, to be a breccia, cemented by a gypseous matter. It is very tough, and weathers in a most angular, rugged manner. The included masses of gypsum are sometimes seen bent and twisted in a most extraordinary way. At one or two of the salt-mines* the salt appears to be in a bed of great thickness, but fissured and cracked, the fissures being filled up with marl. The greater number, however, of the mines are confined to huge detached masses of salt, which sometimes present horizontal, sometimes vertical, lines of stratification, depending on their position at the time they were fixed in the *consolidating gypseous paste.*"

Whilst at Kalabagh, in February 1851, Dr. A. Fleming examined, for a distance of at least twelve miles, the range of hills which run southwardly along the west bank of the Indus, and found there the same Productus-limestone as at Moosakhail, resting on a thin bed of red sandstone and red salt-marl, which just crops out here and there. This range seems identical in structure with the Salt Range, and is flanked on the western side by the same succession of incoherent calcareous sandstone, clays, and marls as before noticed to the north of the Salt Range. In the latest maps this range is well-marked between Esakhail and Kalabagh, and doubtless the sandstones dip under the plain of Bunnoo to rise again and abut on the Teree hills. In his letter, dated March 1852, Dr. A. Fleming observes, that indeed he has no doubt that a large part of the Sooliman Range is formed of the Productus-limestone, as the range at Kaffir Kote (where he has obtained *Productus, Orthis,* &c.) is only the commencement of the Sooliman Range. At Kaffir Kote, however, the nummulite limestone and Jurassic strata have thinned out, and the ossiferous tertiaries rest directly and conformably on a bituminous sandstone, a member of the Productus-limestone series; this series, as in the Salt Range, being based on the red sandstone, &c.

Between the rivers Jelum and Chenab is a level alluvial plain covered with bush jungle. At Korana, however, about forty miles S.S.E. of the Salt Range, and about ten miles from Chuniout on the Chenab, there rise abruptly out of this alluvial plain a series of ridges

* For an account of the salt-mines, see Journ. As. Soc. Bengal, vol. xviii. p. 665.

of stratified rocks dipping, at an angle of 45°, apparently under the Salt Range, and with a strike parallel to it. The most extensive of these ridges is about two miles long, and its highest peak is about 800 feet above the plain. Around this are smaller ridges which emerge from the plain parallel to the larger one within a space of perhaps six or seven miles. These ridges are formed of highly ferruginous and other quartzose sandstones, some of which are in many places distinctly ripple-marked, and quartzose clay-slate, into which the sandstones pass. Some of the sandstones resemble the hardest varieties of Scottish old red sandstone. The whole formation is intersected with quartz-veins loaded with rich hæmatitic iron-ore. The slates appear to be quite unfossiliferous. Dr. A. Fleming is disposed to regard these ridges as outliers which rise out from beneath the lowermost rocks of the Salt Range, and which are not seen along the range itself.

During the hot season in 1851, Dr. A. Fleming, being at the new Hill-station on the Murree Range, was enabled to carry on his researches in another district. "Murree," he says, "is the highest point (7000 feet above the sea) of one of a series of ranges which, rising from the eastern part of the plain between the Jelum and the Indus, N. of the Salt Range, stretch up in a N.N.E. direction towards the Jelum, and seem to be identical with the ranges E. of the Jelum which flank the snowy range of the Peer Punjal. By one only who has been five and a half years amidst the hot winds and dust of the plains of the Punjaub, can the beauties of real hills be fully appreciated. Here we have everything to remind one of home. On the northern slope of all the hills in this neighbourhood are to be seen the most magnificent forests of pine, oak, horse-chestnut, willow, &c., with a thick underwood of hawthorn, barberry, bird-cherry, bramble, &c. The woods abound with Solomon's-seal, Aaron's-rod, woodruff, and wild strawberries; while the more open spots are carpeted with turf covered with white clover, buttercups, and dandelions. Ferns, too, are abundant, but I have only seen three species of three genera,—*Adiantum*, *Asplenium*, and the common English brake—*Pteris aquilina*. The sun is the only thing that reminds one that this is not the land of our birth. In tents I have not yet seen the temperature above 78°, but outside, from 10 A.M. until 4 P.M., the heat is, to say the least, unpleasant. At sunrise the temperature is frequently as low as 50°.

"The geology of this place and neighbourhood is particularly interesting. I have only examined the range on which Murree is situated, from Rawal Pindee, upwards, a distance of forty miles, and generally it may be described as formed of an iron-grey calcareous sandstone, dipping to the N.W. at an angle of from 40° to 50°, and, as far as I have yet seen, devoid of fossils. The southern side of the range is rather steep, but the inclination sufficient to retain a considerable thickness of soil, which for some distance up the side of the hills yields fair crops of wheat, barley, &c., at the season, and

in the autumn, rice. The fields are arranged along the terraces on the strike of the strata, by which means full advantage is taken of all rain that falls; the water which escapes from the upper terraces being caught in some of the lower ones. The northern side of the range presents a gentle slope, and is covered with a thick retentive clay-soil, being, as before stated, richly wooded. Pines, oaks, &c., grow on the south side, but are not nearly so abundant as on the northern aspect.

"The sandstone strata, forming the range, appear to me to be an upper member of the same tertiary sandstones, &c., as occur between Rotas and the Indus. The former differ from the latter, however, in being remarkably compact, forming an excellent building material. On descending into the valley, which separates the Murree Range from another range to the north known as Mooshpoora, and in which the small river Hurroo runs, the sandstone becomes more and more calcareous, passing into a schistose limestone, full of *Nummulites*, with a few fragments of shells, among which I have detected a small *Pecten*, apparently similar to one I have got from the Nummulite-limestone of the Salt Range. This schistose limestone gradually passes into a very compact, fœtid, black limestone, which seems to form the Mooshpoora Range. It contains no flints; and no fossils, except a few *Nummulites*, have yet been detected in it. Its mineral character is very different from the Nummulite-limestone of the Salt Range. I am in great hopes of getting some fossils from it, but the rounded, weathered surface of the rock, the absence of anything like quarries or deep ravines exposing good natural sections, and the generally thick covering of soil, are great obstacles in the way of meeting the information I wish to obtain. As far as I can judge from a distance, it seems to form the top of a hill, which, seen from this spot, is said to be 10,000 feet high*."

On the Geology *of the* Bahamas, *and on* Coral-formations *generally*. By Capt. R. J. Nelson, R.E. Communicated by Sir C. Lyell, V.P.G.S.

[Read June 2, 1852.]

[Abstract.]

Contents.

1. *Introduction.*—This memoir contains a detailed account of an extensive series of observations made by the author during a residence

* Owing to an accident to my instruments, I have been unable to complete my barometric observations.

of two years in the colony, and is accompanied with several maps, sections, and sketches illustrative of the islands, their conformation and structure. A collection also of the corals, shells, and rock-specimens referred to in the memoir have been presented to the Society by Capt. Nelson, and are arranged in the Society's Museum together with the Bermuda collection previously presented by him.

The observations on the Bermudas, written during 1830–33, and printed in the Society's Transactions for 1837*, stand in such close relation, says the author, to those of the present communication, that the latter may be considered as a sequel to the former, justifying the surmise offered at p. 121 of the Bermuda Memoir †, that it is "highly probable that the Bahamas were produced by the same causes as those to which the Bermudas owe their existence;" and showing that both groups are so far identical in character that they may be placed on the same line in any geological system, as a peculiar post-tertiary formation of a composite character, not only of organic ‡ origin, but as Neptunian below and "Æolian §" above.

Capt. Nelson has arranged the results of his observations on the Bahamas, as given in this memoir, as follows:—

Part I. Descriptive.

Section 1. Geographical position and description of the different groups. 2. Occupation of the surface: topographically considered. 3. Construction of coral reefs. 4. Construction of the ordinary rock. 5. Lithological and mineralogical notices. 6. Increase and decrease of land. 7. Fresh water. 8. Flora, and 9. Fauna, as contributing agents. 10. Organic remains. 11. Meteorological notices. 12. Occupation of the surface: economically considered.

Part II. Hypothetic.

Section 1. Probable origin of the Bahamas. 2. On the prominent circumstances affecting the origin, form, and structural character of the Neptunian portions of coral-formations generally. 3. On the term "Formation," and on the position of coral-formations in our geological systems. 4. On the relation between the continental and oceanic ranges of Asia and America.

Part III. Correlative.

Comparative notes on the treatises of the more modern writers on coral-formations:—1. Pacific Ocean, Mr. Darwin; 2. Red Sea, Prof. Ehrenberg; 3. General, Sir C. Lyell; 4. Pacific, Mr. Dana (not finished); 5. Pacific, Mr. Couthony (not finished); 6. Pacific, Capt. Kotzebue; 7. Bermuda, Capt. Nelson; 8. Notices of volcanic

* Trans. Geol. Soc. 2 Ser. vol. v. pt. 1. p. 103 *et seq.*

† *Loc. cit.*

‡ See Bermuda Memoir, *l. c.* p. 111; see also Proc. Geol. Soc. vol. ii. p. 159.

§ I introduced this term in the Bermuda MS., but the passage in which it occurred was inadvertently struck out by myself in making such reductions as were practicable in the bulk of the paper, in which the proposal stood thus: "rejecting the exclusive demands of either Neptune or Pluto, to admit the claims of Æolus to a seat at the Board of Works."—R. J. N.

action in the West Indies, as associated with coral-formations; and original contributions, respecting the West Indian Islands, by the Hon. J. C. Lees, Lieut. C. C. Chesney, R.E., G. Cockburn, Esq., Lieut. Warren, R.E., and Lieut. Grain, R.E.; 9. Notices of the neighbouring coasts of Cuba, Gulf of Mexico, Florida, &c.; 10. Notices of chalk and coral-reef at Barbadoes.

Part IV. Miscellaneous.

A. Relation of pinnacles and caverns, capes and bays, &c., and other subjects in connection with the unequal distribution of mineral matters in solution. B. Mangrove formations. C. Ripple-mark. D. Fresh water in sand-banks and on beaches. E. Notices on Conchs, as contributing to the formation of the chalk. F. Ideal restoration of ancient lagoons. G. Poisonous corals and poisonous coral-eating fish. H. On the use of such terms as "Animal" and "Vegetable." I. Alligators; local extinction of races. J. Testacean reefs. K. Catalogues of the collections accompanying the Bermuda and Bahama Memoirs.

2. *Geographical, topographical, and hydrographical notices.*—The Bahamas, or Lucayos, form a triangular group of islands, islets or cays*, banks, and rocks, opposite and close to the northern mouth of the Gulf of Mexico. This group may be inscribed in a nearly right-angled triangle, whose sides are respectively about 900, 850, and 350 geographical miles in length; the hypothenuse† (900

* Cay or Cays, a low island, corresponding to the Saxon "Holme."

† With regard to the hypothenuse of the right-angled triangle above-described, Capt. Nelson observes that this line, whatever may have been its origin, together with the two other sides, complete a *Delta*, which has been apparently thrown down by the waters of the Gulf Stream on their receiving a check from those of the Atlantic, as they emerge in full strength from the Gulf of Mexico; just as occurs at the mouths of the Nile, Ganges, Mississippi, &c., and of bar-rivers and bar-harbours generally[1]. Although such deposits will be greatly accelerated in formation, and gain much stability, by finding ready-made hilly ground under the sea, nevertheless they can be formed without this; but, taking into account the remarkably symmetrical relation between the sweep of the Bahamas and that of the submarine mountain-range of the Leeward Islands (with which they form a continuous S-like series), as well as the very general absence of shifting sands, it may be surmised that the Bahama Delta *has had* the advantage of such ready-made base and submarine nucleus of aggregation. The sweep of the eastern current[2] may have likewise assisted in the determination of the eastern boundary of the hypothenuse. Capt. Nelson also remarks, that by the latest authorities[3] it appears that the Gulf Stream is brought somewhat lower down in the maps than formerly, as it just touches the southern end of the Newfoundland Banks, and the origin of these last has been referred to the agency of the Gulf Stream. As determining their position in concert with the St. Lawrence and Hudson's Bay currents, the Gulf Stream may have had a considerable effect, but at so great a distance northward we should rather look to the two former currents for the supply of the materials; and this view appears to be supported by the character of the soundings. It is on these grounds that the Bahamas are here called the *Gulf Stream Delta.*

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[1] See Observations on River-bars, Phil. Mag. 4th Ser. vol. v. No. 32. p. 259 and 272.

[2] See A. K. Johnstone's Physical Atlas, pl. 6.

[3] See Johnstone's Atlas, *l. c.*

miles), stretching about N.W. and S.E., quite open to the Atlantic; the base (850) lying parallel to the northern coasts of Cuba and St. Domingo, and separated from the former by a channel at one point not twenty miles wide; the perpendicular (350) forming the eastern side of the Gulf of Florida, and therefore the eastern limit of the Gulf Stream as it wheels sharply to the left round Cape Sable on its way northward. Matanilla Point, Cay Sal Lighthouse, and the Navidad Bank, are the northern, western, and eastern apices respectively of the circumscribing triangle above-mentioned, the central point of which may be said to be in N. Lat. 24°, and W. Long. 76°*.

The Bahamas consist of four great groups, viz. the Little Bahama Bank, the Great Bahama Bank, the Cay Sal Bank, and the Caicos Bank, which comprise numerous islands and islets, and of the minor and less independent groups and detached islands of Great and Little Inagua, Turks Island, Mouchoir Bank, Silver Bank, and Navidad Bank, which are towards the south-eastern extremity of the triangle.

The prevalent winds † are north-east, east, and south-east; and it will be observed, that, generally speaking, the islands are on those sides of their respective groups and banks.

The largest island is North Andros (on the Grand Bahama Bank), which is about fifty miles in length by about thirty in breadth.

The loftiest land in the Bahamas, according to the maps of the Hydrographical Office, is only 230 feet above the sea. Generally speaking, the hills on the larger islands are much under 100 feet in height, and on the islets from 50 to 10 feet. This remarkable lowness of profile is shown by fig. 1.

The surface generally is occupied by low rocky hills, either surrounding basins or forming parts of what may once have been basins, and rarely by distinct hill and valley of the ordinary character. The bottoms of these basins are usually flat and rocky, only a few inches above the average high-water level, and have a rough and cavernous surface. Water, more or less brackish, rises and falls everywhere throughout the lower parts of these flats, though not contemporaneously with the tide‡, or at a uniform rate. The surface is sometimes covered with grass and low bush, and sometimes it consists of the bare rock, full of hollows, which are coated or even arched over with sub-stalagmitic substance. It is in these cavities, locally termed "pot-holes," that most of the soil is found; and in the gardens made on such ground, fruit-trees, pine-apples, Indian corn, sugar-cane, &c. grow luxuriantly. Besides these "rock-marshes §" there are also ordinary marshes and mangrove swamps, of no great extent

* The author particularly refers to the Chart of the West Indies, prepared by Mr. Hobbs, 1849, and published by Wilson, as being worthy of recommendation.

† In Part I. Sect. 11 of his Memoir, Capt. Nelson has placed a series of Meteorological notices, supplied by Mr. Chief Justice Lees, and the following is given as the approximate proportion of winds, on an average of three observations *per diem* for seven years, taking West as 1:—N. $3\frac{1}{2}$; N. to E. 28; E. $10\frac{1}{4}$; S. to E. 24; S. 6; S. to W. $4\frac{1}{2}$; W. 1; N. to W. $6\frac{3}{4}$; Calm $7\frac{1}{2}$.

‡ At Nassau, Bahamas, the tide rises from 4 to 3 feet (Spring to Neap); but at Bermuda it rises from 6 to $4\frac{1}{2}$.

§ There is no rock-marsh at Bermuda.

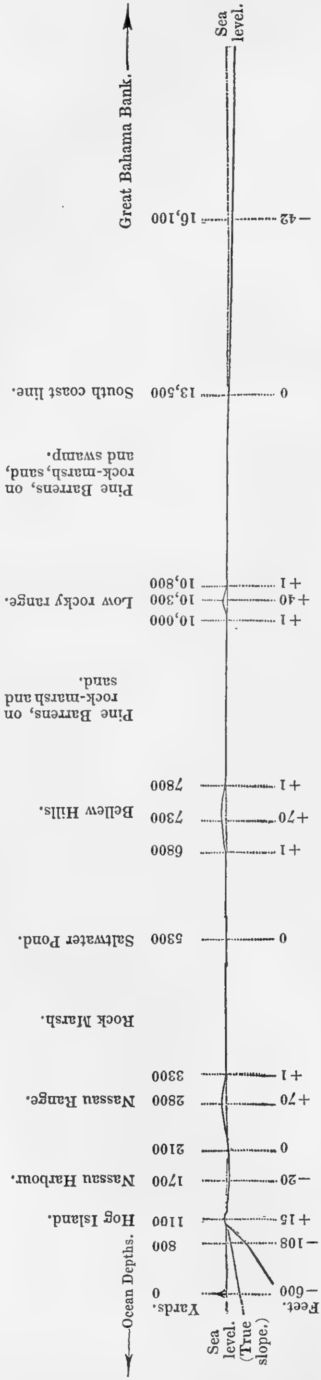


Fig. 1.—*Section through New Providence, Great Bahama Bank, nearly parallel to the Bellew Hill Road, and about 500 yards westward of it. Vertical scale three times greater than horizontal.*

or depth, which are more or less in connection with the sea. On the larger islands the rocky surface of the hills is very thinly and partially covered with "red earth*," mixed in varying proportions with vegetable matter. This scanty soil is fertile, if well used. When uncleared, it is covered with bush and forest trees. There are also sandy tracks termed "pine-barrens," where the bush suddenly disappears and the palmettoes become fewer in number, though enough remain to exhibit an intermixture of Pines and Palms, respectively typical of the northern and southern floras†. The lowest portions of the flat grounds frequently contain small brackish water or salt lakes. In the chalk-marsh of Andros Island, however, there is a freshwater lake, with three streams as its outlets; and it appears that there is no other freshwater lake or stream in the Bahamas.

Capt. Nelson has devoted Section 7. Part I. of his Memoir to observations relative to the occurrence of fresh water in the Bahamas, and supplies an illustrative diagram and tables. It appears that, from the universally porous character of the constituent rock of the islands,

* See notice of this earth further on, p. 208.

† See Humboldt's 'Kosmos,' §. Geography of Plants. Schomburgk mentions the occurrence of Pines and Palms growing together in St. Domingo;—see his Visit to the Valley of Constanza, Athenæum Journal, No. 1291. p. 797.

all the rain* that falls passes directly down, percolating through it to nearly the sea-level. Here it meets with a body of salt water that permeates the lower portions of the rocky structure, and, from its lighter specific gravity, the fresh water floats upon this sea water, rising and falling with the tide, but not contemporaneously at all points, but at a time peculiar to each spot, according to its distance from the sea and the more or less porous condition of the intervening stone. In digging wells, therefore, the shaft is not carried lower down after the first appearance of the "spring" than is necessary to give room for the bucket, so that the salt water may not follow the fresh water into the well. Both salt and fresh water may thus be most certainly met with by sinking a pit at any spot, or in any variety of the rock,—from the denser kind in the large islands, to the mere isolated sand-bank, such as at the S.W. of Memory Rock (Little Bahama Bank), where the wells are mere pits in the sand a few feet deep.

There are large caverns† in Long Cay and Rum Cay; and probably caverns are as numerous in the Bahama Islands as in the Bermudas; but so few extensive excavations have been made, that this cannot be positively affirmed.

In their present submerged condition, such banks as those of Great Bahama, Cay Sal, &c., can only be regarded as tabular rocky expansions, of which the upper surface and sides are covered with sand to various depths. These tabular spaces are marked out to a great extent by a periphery of Cays externally, and by innumerable sunken rocks ("boilers," "breakers," or "ledges") internally.

One of the most striking objects in the topography of the Bahamas is the very deep submarine valley, forming the gulf known as "the Tongue of the Ocean," which runs into the Great Bahama Bank from its northern end. The colour of the water around the islands is usually that of the *aqua-marina* variety of beryl; but the water of the Tongue of the Ocean has the deep blue colour of oceanic depths.

3. *Coral Reefs, Coarse Limestone Rock, and Calcareous Sand Rock.*—The author describes a coral-reef as consisting of masses of numerous species of *Madrepora, Astræa, Dædalæa, Oculina,* bases and axes of *Gorgonia, Millepora, Nullipora, Corallinæ,* &c. &c., growing confusedly together without any other apparent order than that of accidental succession and accretion, both laterally and vertically. These are at times aided or even superseded by *Serpulæ*, &c., as seen in the serpuline reefs‡. In the cavities of the mass, fragments of corals, shells, and other organic remains (perfect or broken), sand, comminuted shells, &c. and chalky mud find their way, and the whole becomes solidified into a compact rock§ by the aid of cal-

* From Mr. Lees' Meteorological notices already referred to, it appears that the approximate annual quantity of rain in an average of seven years is 4 feet 4 inches, giving an average of 1 inch per week.

† Some of these are remarkable for the rude ancient Indian pictures drawn on their walls.

‡ See Bermuda Memoir, *loc. cit.* pp. 116, 117.

§ See also Lyell's Principles of Geology, ed. 7. p. 760–765, for detailed ac-

careous cement, whilst the upward growth of living coral and the accumulation of loose material on the surface proceed simultaneously. Thus the work is ever in progress until it reaches the surface of the water, the loose materials being either dispersed through the crevices and interior of the reef, "packing" and rendering it solid, or else carried out externally in the further and lateral extension of the reef, landward and seaward, so as to form wholly or in part the submarine and compact basis on which the wind subsequently raises other masses having their own peculiar stratification*, with a character very different as regards homogeneity, hardness, density, and organic remains from that of the coral-reef basis.

In Section 4, Capt. Nelson points out a few of the localities that exhibit most clearly the character, source, and mode of aggregation of the materials of the ordinary Bahama rock, such as is formed above the sea level; at the same time referring to the illustrative specimens in the Bahama collection. For instance:—the south side of Silver Cay and the beach extending westward from Nassau afford rolled blocks, pebbles, and sand derived from the more massive corals, mixed with remains of Turtles, Fish, Crustaceans, Echinoderms, and Molluscs. On the beach between Clifton Point and West Bay (specimen No. 1) the shells of *Strombus gigas* more especially accompany the rolled corals. At East Point (specimens Nos. 2 & 3) the sand is derived from Corallines and Nullipores; the finer sand being often in approximately spherical grains, though not so perfectly as at the White Cay (specimen No. 4) and between Exuma and Long Cay. The beach near Charlotteville Point (specimen No. 5) consists principally of *Lucina Pennsylvanica*† in various stages of comminution. At Six Hills (Caicos Group) the mass of Conch shells (*Strombus gigas*) is so great and sufficiently cemented together as to form not only rock, but an island several hundred feet in length‡. Along the N.W. beach at Gun Cay (specimen No. 8), a hard, coarse, stratified rock is formed of Conch and other shells, together with coral fragments. The large fragments of corals and shells are never found much beyond the surf-range of high-tide, and therefore always form rock at a low level; whilst, on the contrary, the fine calcareous sand is removed by the wind and deposited in irregularly laminated beds, which, being consolidated in various degrees, are converted into rock of different qualities§.

counts of the process of the formation of coral-reef and coral-rock at Timor, Sandalwood, Java, &c. as observed by Jukes and others.

* See page 207.

† See Bermuda Memoir, *loc. cit.* p. 111 (*Venus Pennsylvanica*).

‡ A similar mass, about 60 feet long, 8 feet wide, and 8 feet high, occurs in Harbour Island. This drift of shells was thrown up by the hurricane of 1845.

§ See Bermuda Memoir, *l. c.*; Proc. Geol. Soc. vol. ii. p. 160; and De la Beche's Geological Observer, p. 230. It is to these beds, arranged by the agency of the winds, that the author has applied the term "Æolian" (see p. 201). They are of more or less frequent occurrence, especially along sea-coasts, and Capt. Nelson has particularly observed this formation at Algoa Bay and at other places on the coast of South Africa, where they contain remains of existing land and marine molluscs, &c., together with mammalian bones, including those of Man. Infusorial remains, it is said, frequently enter largely into the composition of such accumulations, as in the desert sands of Africa and Arabia. The Æolian rocks at Bermuda, Capt. Nelson

Fig. 2.—*Vertical section of "Æolian" rock, from Mr. Burnside's Quarry, Nassau, New Providence.* Extreme height about 70 feet.

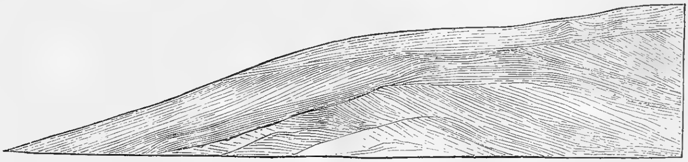


Fig. 3.—*Horizontal section of "Æolian" rock.* About 18 feet long.

The largest and most instructive section in the Bahamas of this calcareous sandstone is that in Mr. Burnside's Quarry, at the end of the road in continuation of Division Street, Nassau, across the hill immediately under Fort Fincastle. The stone is the ordinary "drip-stone" of the Bahamas, and the structure is dome-shaped, presenting, as usual in rocks of Æolian origin, very irregular saddles on every vertical section. See figs. 2 & 3.

4. *Lithological Notices. Ordinary Rock, Chalk Mud, and Red Earth.*—The ordinary Bahama rock everywhere consists of the above-mentioned calcareous sandstone. It is somewhat similar to Portland Stone in appearance, but softer and more porous. When first exposed it is quite white, and is inconveniently bright and dazzling under a tropical sun; but it becomes of a dark ashen grey colour along the sea-coast, and more or less so elsewhere, when exposed to the weather. Its average weight, like that of the Bermuda stone, varies from 95 to 145 pounds per cubic foot. Its inferior value as a building material arises from the numerous sand-flaws (specimen No. 7), and consequent ready failure when exposed to the weather. About the south-west of New Providence, for some feet above the sea, the rock is hard and homogeneous, and may be raised in good blocks for building purposes. The looser and softer kinds of rock are found usually on the hill tops. A variety offering a singular counterfeit of true oolitic structure is found at or near White Cay, Exuma, and elsewhere (specimens 4 & 9); but the spherules are solid, and have been derived apparently from the stems of corallines (see above, p. 206, and specimens Nos. 2 & 3).

remarks, consist more of sand derived from shells than from corals; whilst in the Bahamas the reverse obtains. The hills, formed of these rocks, in the Bahamas do not exceed 230 feet in height, in any instance; in Bermuda they are not more than 250 feet high; in the islands of the Red Sea, however, they attain nearly 300 feet (as noticed by Ehrenberg). In the Pacific Islands the accumulation and consolidation of the Æolian deposits appear to have made but little progress.

A chalk-deposit* is to be found, by all accounts, in the different basins or lagoon bottoms in every principal group, though nowhere so extensively as along the western coast of Andros Island, where it may almost be termed *a young chalk formation*. The extent of this local chalk-deposit is considerable; at its eastern limit it abuts against a narrow ridge of hills along the centre of the islands; the western shore of the islands is generally a stiff chalk bank, 4 or 5 feet high, sloping inwards to the marshy chalk-flat†, which is well overgrown with mangroves, &c., and reaches to the foot of the western slope of the hill-range above-mentioned. Parallel to this western coast and seaward, with a breadth of 14 or 15 miles, the chalk continues in mass as an anchorage; westward again of this, the white mud thins out as a mere covering to the sandy bottom, but still thick enough to preserve the whitish colour over a rudely heart-shaped space of about 80 miles in length by 60 in extreme breadth. The next largest chalk-deposit (but far less in extent) is that in the harbour of Green Turtle Cay.

The "red earth" previously mentioned as forming, generally speaking, the scanty soil of the Bahamas, is at times interstratified with the rock, and sometimes it is incorporated with it. It is identical with the "red earth" of the Bermudas‡ (specimen No. 15) which proved a considerable source of embarrassment, especially with reference to Ireland Island, by seeming to point out alternations of aqueous and other deposits, which were contradicted by the presence of the characteristic *Helix* in all the beds. In visiting a cave near Delaport in 1849, Capt. Nelson found the bottom of the cave for many feet in depth covered with a loose dry "red earth," in grains varying in size from coarse sand to fine dust (specimens 14 & 14 *a*, *b*). Under the microscope this appeared as a mass of insect-remains, the *rejectamenta* of Bats living in these caverns. Specimens of the earth from another part of the same cave, however, were so much altered in character, that they resembled the Bermuda "red earth," and afforded a complete clue to the characters of this substance. Some of the varieties from the Delaport Cave were examined microscopically and chemically by Professor Quekett, of the Royal College of Surgeons, who not only confirmed the above,

* Admiral Roussin compares the chalk, or *tuf blanc*, occurring in many places along the coast, for the space of 1300 miles from the Abrolhos Islands to Maranham, to *mortar*; and this expression is aptly descriptive of the "chalk" of the Bahamas (see also Berm. Mem. *l. c.* p. 114. There was, however, more of the pure white kind at Bermuda). This calcareous mud is derived not merely from the comminution and *decomposition* of Corallines and Corals, and from the *exuviæ* of Foraminiferæ, Molluscs, Echinoderms, Crustaceans, &c., but also from the fæcal *ejectamenta* of Echinoderms, Conchs (see p. 212, note), and coral-eating Fish (*Scari*, &c.). At Bahamas the Angel fish and the Unicorn or Trumpet fish are common feeders on shells and corals. The *Labridæ*, *Raiidæ*, and other fishes are active agents in the comminution of shells. For remarks on the Cat-fish, see Quart. Journ. Geol. Soc. vol. vii. p. 201, note.

† This soft chalk-flat surrounds the freshwater lake of Andros Island, and is inhabited by "colonies" of Flamingoes who build their conical nests in great numbers here, as well as in other parts of the Bahamas.

‡ Bermuda Memoir, *loc. cit.* p. 105, 108.

but announced that all the varieties gave off ammonia, whether retaining organic texture or not. The author thinks it not unlikely that the "red earth," even in the case of the five strata in Ireland Island, has been largely derived from Bats inhabiting once-existing caverns; at the same time, he considers it probable that Birds*, their droppings supplying a sort of guano, have also assisted in the formation of this deposit.

The occurrence of pumice floated ashore at Watling Island, and elsewhere in the Bahamas (as also at Bermuda), is briefly noticed.

5. *Increase and Decrease of Land.*—The present relation of destruction and replacement, as far as the formation of rock above the sea level is concerned, would imply that it is on the wane, and that the accumulation of the once-existing land, of which we have such such extensive wrecks, belonged to another set of operations. But although we do not see the formation of rock in progress above the sea, as at Elbow Bay, Bermuda†, but only the preparation of the materials, yet consolidation is doubtlessly going on below the sea-level.

That however the original constructive power by which the hills were accumulated is still perceptible and can be measured, may be seen, though on a small scale, at Lyford Cay (New Providence). This was an island in 1775, with at times 9 feet depth of water in the channel, which was filled up by 1804, and is now replaced by a sandy isthmus about 10 feet high, covered with creepers, grasses, bush, and palmettoes. Other local evidences of the increase of land are alluded to.

The exposed long linear coral-reefs are peculiarly open to destruction, and the Æolian formations carry an element of destruction in their dome-shaped structure, which on the sea-coast is easily worked into vaults and caverns.

As related to the construction and destruction of land, Capt. Nelson notices in detail the more or less entire belts of rock, which were evidently aggregated at first along, together with, and over coral stripes, at successive epochs, and are all more or less parallel to existing coast-lines, or to the lines of hills in the interior. One of the most complete and extensive examples of these is at the north-east of the Great Bahama Bank, where it is exposed to the ocean, and where it is in a measure fenced in by a quadruple barrier of four lines *en échellon*, each line having apparently once been much wider than at present. The barrier is in various ways carried round the whole of the east, north, and north-west sides of the Great Bahama Bank, generally speaking where most exposed. Cay Sal Bank is likewise contoured by islets and rocks round the eastern, northern, and half of the western margin. The Little Bahama Bank, Crooked Island, Caicos, and Watling Island afford interesting studies of more or less perfect

* Birds are locally very abundant. On Water Cay, near Cay Sal Lighthouse, sea-birds nestle over the whole surface of the island, under every little rock-head that can afford shelter. See also the notice of the Pim-li-co, and the occurrence of bird bones in the red earth, Bermuda Memoir, *loc. cit.* p. 113.

† Bermuda Memoir, *loc. cit.* p. 110.

"Atolls"; whilst such as Silver Bank, Mouchoir, and Navidad are little more than sand-banks.

6. *Flora and Fauna as contributing agents.*—The increase of land in the Bahamas, as elsewhere, is in a considerable degree due to the agency of Plants, either as mechanical or secreting agents. Drifted sea-weed sometimes affords a temporary bond for the sand, in which mangroves*, creepers, grasses, &c.† form further centres of aggregation, their rootlets binding the sand together, and their foliage affording a protection from the wind. The submarine plants, such as Mangrove roots, Turtle-grass, &c., act in an analogous manner, whilst the calciferous plants (*Corallinæ*, &c.‡) not only aid by means of their roots to consolidate the mud and sand, but supply a vast amount of calcareous and carbonaceous material from their own substance. The marshy lands, that are gradually taking the place of the creeks and brackish lakes, abound with, and may be said at some points to consist largely of, a highly calciferous moss-like Conferva §, which, in concert with mangrove roots, grasses, and other

* The Mangrove-swamps of the low moist lands of the tropics are well known. In the swampy clay and sand of the Florida coast the Mangroves form dense jungles, from five to twenty miles broad, and running up the creeks and inlets; and parts of the West Indian Islands (the N.W. inshore coast of Cuba, for example) are extensively occupied with them. The Mangrove (*Rhizophora*) seldom grows more than 15 feet in height; the strength and durability of its timber are very great; and, from its development of roots, and its amphibious habit, it is an important agent in the conversion of swamps and littoral tracts into dry land. There are many species; but the most common in the Bahamas are the Yellow and the White Mangroves. The Yellow Mangrove sends out horizontal roots inland, and into the water it throws down numerous vertical radicles or branch-like roots (to which a variety of living things soon become fixed); it also throws off bud-plants, which, dropping into the water, float until they attain a mud-bank or rock-head, or other congenial point for fixture. The White Mangrove throws down no pendants, but on every quarter it throws off roots which penetrate the mud horizontally about 6 or 8 inches under the surface, and send up suckers at every 3 or 4 inches of their course. Thus each species, by the multiplication of roots and stems, becomes an effective agent in the retention and increase of soil, and frequently both combine in their work of encroachment on the water and formation of land, pushing across creeks and inlets; as is well seen along the N.E. shore of Cunningham Lake, from the ridge between it and the Lake Killarney.

One of the best instances of the *formation of land* that I have ever seen, says Capt. Nelson, was a beautiful little bouquet or wreath of *Spongilla* and *Acetabularia* floating in the water from the end of a Mangrove dactyle, in the rear of which, for a foot or two along the shore, was a loose floating mass of similar, but chiefly dead, material; and in the rear of this again was a compact mass of vegetable soil, consisting of the same material decomposed, and strong enough to bear one's weight tolerably well.

† Ipomæa orbicularis, Artemisia maritima, Rhipsalis, Inula, Gramineæ (repent and fibrous at the root-joints), many species, Coccoloba uvifera, Chrysobalanus icacos, Statice, &c.

‡ Corallina.	Udotea.	Callithamnium.
Nesea.	Acetabularia.	Ptilota.
Jania.	Myriapora.	Polysiphonia.
Amphirhoë.	Nullipora.	Griffithsia.
Halimeda.	Conferva.	Sphæcellaria, &c.

§ Capt. Nelson describes this moss as a spongy mass of laterally aggregated and much-interwoven *fasciculi* of tubes, perhaps $\frac{1}{100}''$ in diameter. On dissolving the chalk secreted by, and coating these tubes, the latter remain as transparent

plants, consolidates and completes the chalky soil. This, like the soil originating with *Acetabulariæ, Spongillæ,* &c. amongst the mangrove roots, is well mixed with carbonaceous matter and well adapted to support vegetation.

Fig. 4.—*Root-like tubular bodies passing through the strata at Cay Sal, and exposed by weathering.* Tubes from $\frac{1}{10}$ inch to 2 inches in diameter.

In a fossil condition the traces of plants are obscure; at some places, however, the rock is extensively traversed by contorted, irregular, stony tubes, of various diameters from $\frac{1}{10}$ to $1\frac{1}{2}$ inch, exhibiting an appearance of having been aggregated round long slender roots, or even stems, that have since perished. These pass through the strata or not indifferently; sometimes they are exposed by the waves and weather and stand out as disengaged masses of tubes (see fig. 4), as in the low cliff under Gun Cay Lighthouse, and elsewhere. Rudely cylindrical bodies also, from 9 to 12 inches in diameter, generally imbedded in and filled with red-earth-rock, appear in transverse sections along the road-cuttings; their character is very equivocal, even more so than those at Bermuda*. Small root-like bodies also are often imbedded in the red-earth-rock. Nearly all the Bahamas abound in these tubular concretions.

Of animal organic bodies, the Corals† are by far the greatest contributors, both as affording materials and as retaining loose sand, &c. mechanically. Of these the *Madrepora*‡ (in the sense used by Ellis) is the most important. It occurs in mass and affords sand. *Zoanthe* (*Z. sociata* and an unnamed species, which is much more

cellular fibres. Capt. N. observes, that when fresh, the moss has a strong odour of iodine.

* *Loc. cit.* p. 115.

† Seas may be prolific, says the author, in zoophytes, dispersed in small groups or low sloping banks, without their having any very obvious tendency to form abrupt reefs, which last, I believe, are not now to be found in the Bahamas. In Hanover Sound, for instance, the bottom is a zoophytic garden of most interesting subjects, but there is very little appearance of the labyrinthine reefs that obtain in Bermuda, especially along its north-east and south-east portions.

‡ M. cerebrum; 2 or 3 varieties.	M. galaxæa.
M. porites, branched and massive.	M. muricata; 2 or 3 varieties.
M. undata.	M. areolata.
M. astræa.	M. labyrinthica.
M. rotulosa.	M. phrygia.

All abundant except *M. undata.*

Near East Point, New Providence, occurs a remarkable accumulation of broken Madrepores, imbedded in a dark grey rugged rock, at and a little above high-water mark, which, however, does not belong to the coral-reef basis.

abundant at Bermuda) supplies chalk. *Gorgoniæ* (many species) afford strong connecting and retentive bonds. *Palmipora alcicornis** (specimens 17 & 18) is always a remarkably accretive agent, and it contributes also a soft sand. Echinoderms and Crustaceans are also abundant, supplying fragments and soft sand. *Serpulæ*† contribute extensively in mass and otherwise.

Of Mollusca, the *Strombus gigas*‡, *Turbo pica*§, *Venus* (*Lucina*) *Pennsylvanica*‖, and *Pupa chrysalis*¶ are some of the most important contributors, both in mass and as sand. The bones of Fish and Reptiles (*Chelone midas, C. caretta,* and probably the Alligator**), are more or less abundant, but are soon triturated into soft sand and mud.

Lastly, as regards the contributory agency of animal life in the increase of the land, mention was made at p. 209 of the fact of Birds, Bats, and Insects having added very considerably to the soil and rock of these islands.

7. *Elevation and depression of the land.*—Whatever may be the real foundation of the Bahamas,—whether, like the West Indian Islands generally, they are indebted to igneous agency for their existence as elevated masses, or otherwise,—there is *no evidence* of such elevation having taken place either in the Bahamas or Bermuda. On the contrary, the total absence of coral-reefs in mass, or even of

* This Zoophyte ? is most abundant at Bermuda, but not very plentiful at the Bahamas.

† See Berm. Mem. *l. c.* f. 18. p. 117; and Bermuda specimens Nos. 40 & 41; also Bahama specimens in the Society's Museum. Capt. Nelson observes that the Serpuline reefs, though at first merely incrustations, become thick masses, very solid and hard, and are capable of indefinite extension. The *Serpulæ* will bear exposure a half-tide, or rather more, out of water, to the height of spring floods.

‡ See Section 4, p. 206, *supra*. This shell often preserves its colour and nacre in the rock. Capt. Nelson points out how considerable an agent (like the *Scarus* and *Holothuria*, noticed by Mr. Darwin) the Conch is in adding to the chalky mud of the West Indian seas, by means of its fæcal pellets, which, when freshly voided, are cylindrical masses made up of numerous minute grains of soft calcareous matter, together with some organic tissue.

§ The shell of *Turbo pica* occurs with its colour and nacre perfect at the sea-level, even at a depth of 50 feet (in borings on high ground). This shell is also found here, as at Bermuda (*loc. cit.* p. 111), *in the Æolian rock* of the higher grounds, having been carried up by the Hermit Crab.

‖ See Section 4, p. 206, *supra*. Capt. Nelson refers to a like important part played by a species of *Pectunculus* in forming a thick littoral deposit near Jaffa, in the Levant.

¶ The shells of *Pupa chrysalis*, Férussac (Specimens 12, 13), occur in the rock at all depths to which the quarries are worked. In the living state this *Pupa* is to be met with in abundance, crawling about bushes, grass, reeds, &c. Small *Helices*, now living at Bermuda, are found under analogous circumstances, from the top to the bottom of the Bermuda rock (see Berm. Memoir and specimens).

** The egg of the Alligator is said to have been found twice in Mr. Burnside's Quarry (see above, p. 207), at a few feet above the sea-level. The Alligator has become extinct in Andros Island in the course of about a century, for Alligators were plentiful in the mangrove swamps of the island in 1726, when Catesby mentioned them in his work, but none have been seen during the present generation. Although not large, alligators are still numerous in both Crooked Island and Aclins Island.

detached coral blocks, *above* the tide-line leads us to the supposition that no upheaval has taken place during the present epoch. Nor is any reference to an upheaving agency called for to account for the slight elevation of the dry flat bottoms of the old lagoons, now filled in with rock-marsh*, for the existing natural process of the formation of land in creeks and lagoons by means of mangroves and calciferous confervæ,—with or without the preceding assistance of sea-weeds, corallines, deposits of chalk-mud, and sand-drifts,—shows that organic agency, direct or indirect, is quite competent to the task of raising the surface to the height required.

The fact of detached blocks of coral being found *in* the rock at considerable distance from the sea-coast *at the tide-level*, proves that no subsidence has taken place during the present epoch. Conch-shells† also, either dispersed or in beds, are found by the well-diggers in the solid rock at about the sea-level, and thus bear evidence to the same fact.

8. *Ripple-mark and its protection.*—Capt. Nelson observes, in Part IV. Section C. of his Memoir, that the extent to which surface-action affects the ground under water is a matter of importance to the Engineer and of interest to the Geologist, not only as regards Ripple-mark,—which may be considered as the record of a self-registering oscillatory motion of a fluid among relatively light pulverulent bodies on which it lies, and which may be seen also on snow and sand‡ exposed to any similar reverberatory action of the wind (and indeed the clouds, in the state of "mackerel-sky," may perhaps be said to exhibit an *atmospheric ripple-mark*),—but also with respect to the preservation of the tracks of Annelids, Molluscs, Crustaceans, Birds, Reptiles, &c.; and in connection with this subject he quotes the following from his journal:—Gun Cay, December 31, 1850. In 20 feet of water the ripple-marks and the imperfect scorings made by the cable on the white-sand, before it settled down where anchored last night, were wonderfully perfect this morning; the water having in nowise destroyed the sharpness of the impressions. The sea is as exquisitely clear at the Bahamas as at the Bermudas; and, when it has been quite calm, I have seen not only the ripple-mark quite plainly, but the small plants, &c. growing below, and the worm-heaps, at a depth of 11 fathoms; and the floating corpuscles,—animate or inanimate,—organic or inorganic,—could be seen very distinctly by oblique light, as they emerged from the shadow of the vessel (seen as distinctly on the sand as if it had fallen directly on the land), like dust in a pencil of light traversing a darkened room. Judging from this, and from what I caught in the muslin net this morning, it is probable that the coating of sand in which these ripple-marks, &c. will soon be cased, will be rich in remains of minute organisms, notwithstanding the generally deliquescent character of their substance.

Conclusion.—The author's observations with regard to the Bahamas

* See above, p. 203.

† See above, pp. 206 and 212.

‡ Proc. Geol. Soc. vol. ii. p. 160.

(collected from Part I. of his Memoir, and separate portions of the other Parts) are condensed in the foregoing pages; but there still remains much interesting matter, as will be seen by reference to the contents of memoir, given above (p. 201). With regard to Coral-formations generally, there are many notes on Ehrenberg's and Darwin's Works on Coral Islands, &c.; and remarks are made on the Zoophytes, &c. forming reefs;—Atolls;—Æolian Sandstone;—increase and decrease of land;—chalk deposit;—angle at which sand stands; &c. There is also a series of original observations, on the geology of different parts of the West Indies and of the adjacent coasts of Cuba and America, by Officers of the Royal Engineers and other friends of the Author. And Capt. Nelson states in the introductory portion of his Memoir that he wishes it to be understood, that "as the results of the exertions of every officer in our corps are all Corps property, the corps of Royal Engineers has contributed to the general stock of geological information"—the first notice of the Æolian formation; taking rank with the Neptunian and the Plutonic:—the first discovery of any origin of chalk* (in 1832), soon followed by Mr. Darwin's perfectly independent discoveries in the Pacific, and by Lonsdale's and Ehrenberg's microscopical discoveries:—two modes of completing the change of a coral-formation from a marine condition to that of *terra firma*, viz. by the agency of *mangroves* and *calciferous confervæ*:—observations on the impossibility of establishing a distinction between the animal and vegetable kingdoms:—and, lastly, the discovery of the character of the "Red-earth," which, there is reason to believe, occurs extensively in the West Indies and elsewhere.

The author regrets that the indifferent state of his eyesight prevents the prosecution of his researches in the history of corals and collateral subjects, and that it does not admit of his carrying out his design with regard to Part III. of his Memoir by comparing and examining the works of Couthony and Dana, as has been done with those of Ehrenberg and Darwin.

Corrections to be made in the Bermuda Memoir. Trans. Geol. Soc. 2 Ser. vol. v. part 1. p. 103 *et seq.*

Page 103, note, *for* Tilden *read* Tylden.
— 108, fig. 5, the more or less horizontal lines in the section, fig. 5, which are nearly conformable to the existing surface, should have been more distinctly indicated as the ancient successive surfaces of the "red earth."
— — line 7 from bottom, *for* masses of corals *read* masses of corals within surf-range.
— 110, — 8 from top, *for* Quenodis *read* Quenvais.
— 111, — 7 from top, *after* may be found } *read* within surf-range.
— 112, — 9 from top, *after* high water }
— — — 11 from top, *for* Millepore *read* Nullipore.

* Berm. Mem. *l. c.* p. 114.

Page 112, line 20 from top, *for* would have been altogether evolved and would not have remained *read* would not have been altogether evolved and would have remained.
— 113, — 25 from top, the buckle was said to have been found in a block of stone near Hamilton.
— 117, Diluvial agency. The action of wind on dry sand or snow, and of water on submerged earth or sand having similar results in forming hilly surfaces; we need not refer all the contour phenomena of these islands to " diluvial " agency.
— 118, lines 8–10 from top, The red earth having been now shown to be of organic origin, the argument in the text is no longer valid.
— 119, lines 9, 10 from top, Diluvial action. These phenomena are not necessarily attributable to diluvial action; for the upper crust of the caverns may have fallen in on the withdrawal of their contents by the sea, although the then existing connection with the sea may have been since filled up.
— 120, line 17 from bottom, *for* Picton *read* Pictou.
— — — 5 from bottom, *for* Mr. Langton's *read* Mt. Langton.
— 123, — 4 from top, *for* sound *read* sand.

Note.—The sand encroachment at Elbow Bay (see Bermuda Memoir, p. 109) has now crossed the hill at certain points. Capt. J. Gordon, R.E., informs the author that it has risen to the height of the chimney of Keel's cottage, and is now in course of swallowing up Mr. Dunscombe's property.

On a Proposed Separation *of the so-called* Caradoc Sandstone *into two distinct Groups;* viz. (1) May Hill Sandstone; (2) Caradoc Sandstone. By the Rev. Professor Sedgwick, F.R.S., F.G.S.

[Read November 3, 1852.]

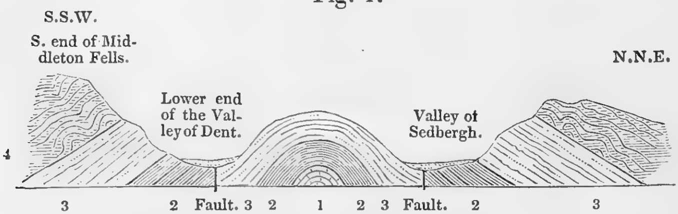
In former papers, read during the sessions of the past year, I endeavoured to show that between Ravenstonedale and Horton in Ribblesdale, and along an irregular line which runs on the east side of the great Craven fault, the older palæozoic rocks are based on three distinct groups of strata: (1.) The Coniston limestone and calcareous slates; (2.) The Coniston flagstone; (3.) The Coniston grits. The first two were brought into comparison with the upper part of the Bala series, while the third was considered as the true equivalent of the Caradoc sandstone*. As, however, between Helm's Gill, in the valley of Dent, and Thornton Beck near Ingleton, there was an interval of full ten miles in which no distinct traces had been discovered of the Coniston limestone and calcareous slates; I requested my friend John Ruthven carefully to re-examine the country, with a view of discovering some additional traces of the Coniston group (No. 1); and, above all, of collecting fossils, wherever they were to be found, in the hard sterile ridges of the Coniston grits.

Those who have read the papers, formerly published in our Transactions, will have some remembrance of the structure of the valley of Dent. All the higher parts of the valley are composed of nearly horizontal beds of the Carboniferous series crowned by the Millstone

* Journal of the Geological Society, vol. viii. p. 150, &c.

grit; while all the lower parts (commencing about a mile below the village and to the west of the great transverse Craven fault) are composed of the three groups of older rocks, above mentioned, which are sometimes highly inclined and contorted. A great fault runs down the valley of Dent, and a similar fault runs also down the valley of Sedbergh, in consequence of which the Coniston grits (the most striking of the older palæozoic rocks of the neighbouring country) are repeated at the north end of Middleton Fells, and at the south end of Howgill Fells; as may be illustrated by the accompanying section. These faults and flexures do not at all affect the Carboniferous series, and evidently took place before the period of the Old-red-sandstone.

Fig. 1.



1. Coniston limestone and shale.
2. Coniston flags.
3. Coniston grits.
4. Ireleth slates (=Wenlock).

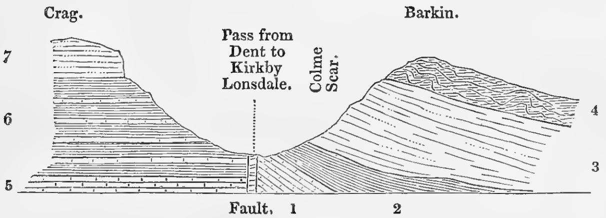
The great Craven fault, on the contrary, took place, for reasons stated in former papers, after the Carboniferous rocks were complete, and just before the period of the New-red-conglomerates. It crosses the valley of Dent nearly at right angles to its direction, and produces a singular effect on the whole features of the neighbouring country. In some places the carboniferous and the older palæozoic rocks are separated by deep valleys, excavated nearly on the line of the great Craven fault, and these valleys are not unusually much filled with drifted matter which conceals from view any junction of the older with the newer Palæozoic series. In other situations (especially on both sides of the valley of Dent, and thence down Barbondale) the two systems are seen to abut, one against the other; being simply divided by the broken, and often nearly vertical, masses of carboniferous limestone which mark the range of the Craven fault.

In former papers I have described in sufficient detail the junction at Helm's Gill on the north side of the valley of Dent, and I will now shortly notice the corresponding phænomena on the south side of the valley where the two systems are seen (at the head of the pass leading from Dent to Kirkby Lonsdale) to abut one against the other. The general facts may be illustrated by the following, partly ideal, section (Fig. 2).

There could be no reasonable doubt that the groups of this section must be identical with those of Helm's Gill, which commence with the Coniston limestone; but the lowest beds (No. 1) are so ill exposed, or so much displaced by ancient land-slips, that I had not, during former visits, been able to trace distinctly the Coniston beds

through them. During a short visit to this locality, in the month of September, I met my friend John Ruthven, who had been some time employed upon the task to which I have before alluded; and I found that he had already discovered some good characteristic Coniston corals and shells among the watercourses near the top of the pass. We then examined together some broken ground which has now been cleared of wood; and in several places (especially near a farm called Bowerbank) we had access to the bare rock, which contained well-known fossils (such as the *Trinucleus Caractaci,* &c.) of the Coniston limestone and calcareous slates. The evidence was therefore now complete.

Fig. 2.



1. Coniston limestone and shale.
2. Coniston flags.
3. Coniston grits.
4. Ireleth slates (=Wenlock).
5. Upper beds of the Great Scar limestone.
6. Limestone and shale in alternations.
7. Millstone grit series.

The facts here stated may seem too trifling to deserve notice. They show, however, how true, in this part of England, nature continues to her own type; and they partially help to fill up, by a good symmetrical section, that interval of ten miles, above mentioned, between Helm's Gill and Thornton Beck. In the lower parts of Barbondale, it would be in vain to look for the Coniston beds, because unequivocally newer beds, about the age of the Wenlock shale, are, by the great flexures of Middleton Fells, made to abut against the line of fault. By a great reversed dip the Coniston grits are, however, again brought out on Casterton Low Fell; and I think it just possible that in the deep water-course on the south side of that Fell, the Coniston beds may be hereafter discovered.

So far as I could make out from a very obscure section, the lowest group (No. 1) is of very considerable thickness, and is made up of dark shaly beds containing many bands so calcareous as almost to pass into limestone. Whether there may exist any well-defined bed of limestone near the base of this group (as at Coniston), it is impossible to tell; but the calcareous slates just noticed seem to encroach upon the Coniston flags (No. 2 of this section), which, at the point here described, do not seem to be more than 400 or 500 feet in thickness*.

* Near Coniston the flags are, I think, full three times the thickness here given.

The Coniston grits (No. 3) are magnificently brought out in the great precipice called Colm Scar, and are of far greater thickness than the flags; and near their eastern end they are traversed by a dyke composed chiefly, like many others in the neighbouring mountains, of flesh-coloured felspar and black mica.

But are the Coniston grits the exact equivalents of the rocks, which in North Wales and Shropshire, &c., are represented, on the Government Map, under one colour, as Caradoc sandstone? To answer this question fully would require such a series of fossils as no one has yet discovered, or perhaps ever will discover, in these hard sterile grits. When I gave notice of this paper, I hoped, before it was read, to have before me the last result of John Ruthven's labours. Unfortunately I have not yet received from him a single specimen, beyond those we collected together during a single day's labour on the section just described. I may, however, express my full conviction that the question implied in the title of this communication cannot be settled by an appeal to the Coniston grits, but must have its final answer determined by the more complete evidence exhibited in the more perfect sections of Wales and Shropshire, which gave to Sir R. I. Murchison the base and superstructure of his "Silurian System."

Deeply do I lament that inevitable engagements prevented me, during the summer months, from undertaking a joint labour with Professor M'Coy, which I had long thought of, and believed it possible to complete in four or five weeks; viz. of examining some of the best sections through certain groups of strata which have hitherto been described as Caradoc sandstone; and, as such, are represented by one colour in the beautiful published sheets of the Government Survey, as well as in the Maps and Sketches that accompany Professor Phillips's Memoir*. We could not begin our task before Tuesday the 21st of September, and on the Monday following we were reluctantly compelled to abandon our task. We did, however, examine the so-called Caradoc sandstone of May Hill, and the corresponding deposits on the west flank of the Malverns, in perhaps sufficient detail for our express purpose; and we bestowed some labour on the well-known Horderley section, the upper beds of which were, however, concealed by the swollen state of the river Onny. Our attempt on the Soudley section was almost entirely defeated.

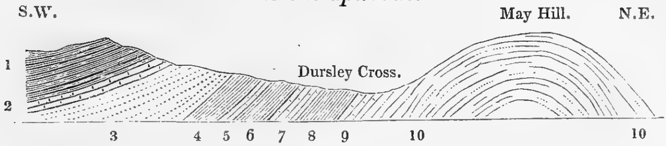
Had the sections been previously unknown to us, it would have been utterly impossible to make, in so short a time, any approach to their true interpretation; but we had only to examine sections which had been already described in ample detail; and we confined our inquiries to one simple question; viz. whether the so-called Caradoc group might not be naturally subdivided into two or more distinct groups in conformity with the indications of the fossils?

May Hill.—Of the beautiful Silurian sections, those which cut through the Woolhope elevation, and those which connect the coal-field of the Forest of Dean with the sandstone axis of May Hill, are perhaps the most clear and instructive. It would be idle for me to

* Memoirs of the Geological Survey of Great Britain, vol. ii. part i.

detain the reader one moment in a general description of these well-known sections; and the accompanying sketch is simply used to help the memory, and to give coherence to the subjoined remarks.

Fig. 3.—*Diagram showing the succession of rocks from the May Hill Sandstone upwards.*



1. Coal-field of the Forest of Dean.
2. Mountain limestone.
3. Old Red Sandstone.
4. Upper Ludlow.
5. Aymestry limestone.
6. Lower Ludlow.
7. Wenlock limestone.
8. Wenlock shale.
9. Woolhope limestone.
10. May Hill sandstone.

The Woolhope sections are the most perfect and symmetrical; but the May Hill section was best for our purpose; viz. to examine, and connect together, the two groups which are at the base of the section. In the May Hill section we have the following groups in true descending order:—1. The Carboniferous series; 2. The Old-red-sandstone; 3. The Ludlow series (Nos. 4, 5, 6 of the sketch); 4. The Wenlock series (Nos. 7, 8 of the sketch). Respecting these four groups there has been no doubt since the Silurian Sections were first published by Sir R. I. Murchison. 5. These groups are followed by thin bands of concretionary limestone (No. 9 of the sketch), separating the base of the Wenlock shales from the underlying grits of May Hill. 6. The shelly sandstones and grits which form the dome-like elevation of May Hill (No. 10).

The last two groups of this section were considered, in the "Silurian System," as Caradoc sandstone. Subsequent labourers, especially Professor Phillips, have pointed out good reasons for regarding the bands of concretionary limestone as an integral part of the Wenlock series; but he and the other Government Surveyors have coloured and described the May Hill grits, &c. as Caradoc sandstone.

The bands of limestone last mentioned might, I think, be most conveniently called *Lower Wenlock limestone*; but the name *Woolhope limestone* having for some time passed current, I will here adopt it. All the Silurian limestones are local phænomena; none of them are so persistent as to offer good terms of comparison between countries, of the same age, which are widely separated. This remark applies with all its force to the Woolhope limestone. Round May Hill it is in many places so degenerate as to have been overlooked in the sections. At Littlehope (and in other places within the Woolhope elevation) it is more clearly developed, and cannot escape notice, as it is extensively burnt for lime. At Presteign it reaches its maximum of development; and it there so entirely resembles the most complete form of Wenlock limestone, that for many years it was confounded with that rock*.

* See Quart. Journ. Geol. Soc. vol. vi. p. 435.

In the great development of the Silurian rocks of Denbighshire we lose, I believe, all traces of the Woolhope limestone; and in many parts of Westmoreland and Lancashire it disappears, with the other Silurian limestones, entirely from among the older palæozoic rocks. Still it deserves remark, that in the range of the true Silurian rocks of North Lancashire, from a part of Low-Furness to the foot of Coniston-water, we find in several places the Coniston grits overlaid by discontinuous beds of concretionary limestone, which, with my present views (for I would, provisionally, identify the Coniston grits with those of May Hill), I should not hesitate to bring into near comparison with the Woolhope limestone.

On the south side of May Hill the Woolhope beds are not merely degenerate and concretionary, but they alternate with, and pass into, a yellow soft decomposing sandstone, which, here and there, contains many ill-preserved fossils. In this way the beds in question seem to form a distinct mineral passage into the upper beds of the central dome of May Hill: and, by way of conclusion, I may remark, that all the fossils of the group under notice were of Wenlock species, without any admixture of those types which (using the nomenclature of my former paper) are characteristic of the higher groups of the great Cambrian series.

Dismissing the Woolhope limestone, we next come to the great central mass of May Hill. Its upper beds, which are of a very considerable thickness, contain many well-preserved fossils. The lower beds of the dome, which crop out as we advance towards its summit, are more coarse, are sometimes very ferruginous, and here and there become so coarse as to pass into a conglomerate. These lower beds are ill-exposed, and we had very little time for their examination, nor did we obtain from them one single fossil. But from the shelly sandstones which form the south brow of May Hill, and descend unequivocally under, and *pass into,* the above-mentioned Woolhope beds, I am enabled to give the following list of fossils, obtained during two visits, by the joint labours of Professor M'Coy, Rev. P. B. Brodie, and myself. The names are, of course, given on the authority of Professor M'Coy:—

List of the May Hill Fossils, &c.

The letter (W.) is affixed to such species as are known in other undoubted Wenlock localities.

Petraia bina (W.).
Palæocyclus porpita (W.).
Halysites catenulata (W.).
Favosites Gothlandica (W.).
—— *multipora* (W.).
Cornulites serpuloides (W.).
Encrinurus punctatus (W.).
Spirigerina reticularis (W.).
Spirifera crispa (W.).
Hemithyris navicula (Ludlow).
—— *marginalis* (W.).
Pentamerus lens (Malvern).
—— *linguifera* (W.).
Orthis turgida?
—— *Davidsoni* (W.).
—— *hybrida* (W.).
Leptæna transversalis (W.).
Strophomena simulans? (Malvern.)
——*funiculata* (W.).
—— *pecten* (W.).
Leptagonia depressa (W.).
Euomphalus funatus (W.).

"Of the above twenty-two species, nineteen are well known in the undoubted Wenlock or superior strata of other districts, and are all

well-preserved and clearly distinguishable; two of the remaining three are such imperfect casts that I can but doubtfully indicate them. One of these two and the third (*Strophomena simulans* and *Pentamerus lens*) occur at Malvern also with Wenlock fossils. The shell which I figured (Synopsis of the Silurian Fossils of Ireland) under the name *Spirifer ovatus* has been found by Mr. Salter to be identical with the distorted cast named *S. liratus* by Sowerby, and I now can prove it, from the May Hill specimens, to be the exterior of the *Pentamerus lens*. The *Orthis Davidsoni* is an *exclusively* Wenlock limestone species described by MM. Davidson and De Verneuil, confounded in this country with the totally different *Orthis flabellulum* of the true Caradoc sandstone and inferior beds. With the exception of the three doubtful species alluded to, there is *no fossil* in the above list *which is not well known* in the Wenlock limestones, and some of them are peculiar to it." (Professor M'Coy.)

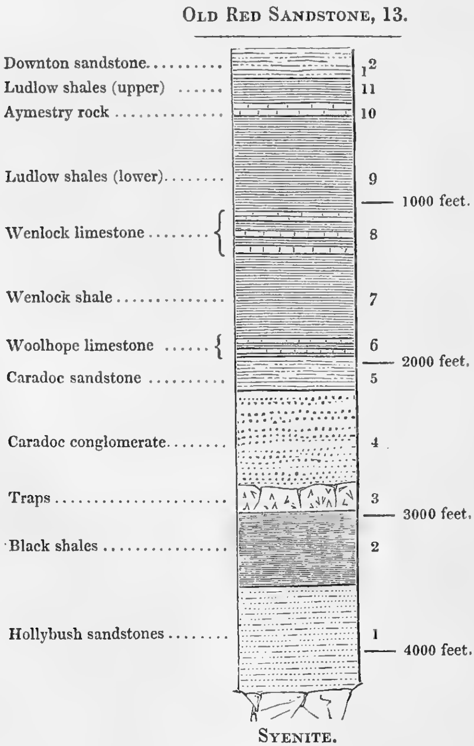
In this list there is, then, no *admixture* of those peculiar types which are respectively supposed to characterize the two great divisions (Cambrian and Silurian) of the older Palæozoic series. It is a true and characteristic Wenlock list, and whatever reasons there may be for grouping the Woolhope beds with the Wenlock series, the same reasons apply, with all their force, to the May Hill fossiliferous sandstones; and with perfect propriety they might be named Wenlock grit or Wenlock sandstone. For the present, however, I would call them May Hill sandstone, and unquestionably separate them from the well-known sandstone between Caer Caradoc and the great terrace of Wenlock Edge. And let me here remark, that whenever, in this paper, I use the words *Caradoc sandstone*, without any explanatory phrase, I mean to designate a group like that of Horderley or Caer Caradoc, containing the well-known fossils of the great upper Cambrian or Bala group. With this limitation, the true Caradoc fauna is very widely distinct from the fauna of the May Hill sandstone: and the term Caradoc is thus limited to strata which are the true equivalents of those which first suggested the name—Caradoc sandstone. Whether, in the centre of the dome of May Hill, there may not be some older beds with a different group of fossils, is a point we had no means of determining, and I write only from the evidence now before me.

Sections on the West Side of the Malvern Hills.

Some of these sections are very complicated, and the great merit of first reducing them to order is due exclusively to the author of the 'Silurian System.' In the elaborate and excellent survey of the Malvern Hills and the neighbouring districts (published in the Memoirs of the Government Geological Survey in 1848, nearly ten years after the first appearance of the 'Silurian System'), Professor Phillips made some important corrections of, and additions to, the original published sections. These corrections were not, however, of such a nature as to detract from, but rather to add to, the great merit of the original survey; and he seems to have been so much under the influence of this sentiment, as to have retained the original nomenclature of "the

Silurian System" in some cases where the evidence adduced by himself pointed, as it appears to me, by a true logical inference, to some modification in the naming of the groups. Thus he continues to designate the May Hill grits by the name Caradoc sandstone, though their fossils are almost identical with those of the Wenlock beds. In describing the Usk district he has indeed changed the nomenclature and elevated certain beds, previously called Caradoc and Llandeilo, into the Wenlock period; and after having done this he adds—"that here (in the Usk district) is a second instance, more remarkable than that already established on the western side of the Malvern Hills, of the deposition of sandstones, mineralogically of the Caradoc type, in an ocean filled with the life of the Wenlock period." (Memoir, p. 202.)

Fig. 4.—*Diagram showing a vertical section of the Lower Palæozoic Rocks in the Malverns.* (After Phillips; Memoir, p. 51*.)



If the fact be admitted, that certain beds (at May Hill and the Malverns), "although mineralogically of the Caradoc type," contain

* In accordance with the views of this paper, we should call Nos. 4 and 5 by the names May Hill conglomerate and May Hill sandstone.

a good Wenlock group of fossils, it seems, in sound logic, to confirm rather than invalidate my previous conclusion, viz. that the May Hill sandstones are a part of the Wenlock group, and not a part of the true Caradoc group. That these sandstones of May Hill are a part of the true Wenlock group, appears from their place in the section, their passage beds, and their fossils. And spite of the continuance of an older mineral type, which apparently offers good conditions for the uninterrupted life of the older (or Cambrian) species, such species are not continued, so as to pass upward into the May Hill sandstones.

The sections on the West side of the Malverns are so well known to all who can take any interest in this paper, that I hardly need copy or discuss any one of them; but I think it expedient to copy the vertical, ideal, section, in which Professor Phillips represents the whole series of the palæozoic groups which are brought out on the western slopes of the Malvern Hills (Fig. 4).

The above ideal vertical section applies specially to the sections here under notice, and is, I believe, perfectly accurate. Nos. 1 and 2, the *Hollybush sandstone* and the *Black shales*, here skirt the bosses of syenite, in the manner described in detail by Professor Phillips, and form the base of the series hitherto described collectively under the name of Caradoc sandstone. Adopting this nomenclature, so far as I believe it tenable, I should provisionally call No. 1 Caradoc sandstone, and No. 2 Caradoc shale; which, I believe, agrees with Professor Phillips's view*. This sandstone is unfortunately very sterile of fossils; but along the western skirts of the Malvern syenites, there are (as has been described in the Memoirs of Murchison and Phillips) several spots in which groups of rocks are found containing fossils. And should any of the beds, in this skirting position, contain a group of true Caradoc fossils, we should, of course, place them at the base of the Malvern series; but, north of Hollybush, no such beds fell under our notice.

The *Black Shales* (No. 2) are so interlaced with the neighbouring sandstones as not, I think, to be separable from them. This is also the published opinion of Professor Phillips. There is nothing in the mineral structure of the shales to indicate a rock of great antiquity; and if this remark were regarded as of little moment, I should add, that there is nothing in the position of the shales to indicate the fact that they had been anomalously protruded among the neighbouring sandstones. This opinion of an anomalous protrusion of a very ancient rock (viz. the Tremadoc slate, which is low in the great Cambrian series) was not vindicated by Prof. Phillips; but has no doubt been suggested by the fact (first published in his Memoir), that imperfect portions of two small new species of *Olenus*, and the fragment of another doubtful species, had been found among these Black shales. Assuming, without reserve, the truth of these determinations, what do they appear to prove? Only that the genus *Olenus*, which began during the very early deposits of North Wales, still existed, though very rarely, during the period of those rocks which form the newest members of the great Cambrian series.

Much time was lost by Prof. M'Coy and myself in seeking for the

* Memoir, p. 53.

Oleni; and I believed that we failed in finding them from the want of a good pick-axe, which I would recommend to all geologists who are disposed to attempt the task in which we were defeated.

"*Caradoc Conglomerate and Purple Shales,*" *&c.* No. 4.—We were very reluctantly compelled, from want of time, to give up our examination of the whole section from the south end of the Syenite hills, over Howler's Heath, to the Woolhope limestone. We therefore left this section half-finished, and made a traverse to the Eastnor Park Section, wishing especially to examine the well-known fossiliferous quarries, in the brow of the hill on the south side of the obelisk. "The thick, soft, purplish, and grey and brown sandstones under the obelisk are (as Professor Phillips states*) a good example of a part of this group" (No. 4). Fossils are very abundant in this locality, first brought into notice by Sir R. I. Murchison. We collected, almost exclusively from one well-known quarry, the following species:—

Favosites Gothlandica (W.).
Stenopora fibrosa (W.).
Cornulites serpularius (W.).
Spirigerina marginalis (W.).
—— *reticularis* (W.).
Pentamerus galeatus (W.).
Orthis elegantula (W.).
—— *hybrida* (W.).
Leptæna minima (W.).
Lingula, sp.
Hemithyris diodonta (W.) (=*bidentata*).
—— *lacunosa* (W.).
Strophomena englypha (W.).
Pterinea retroflexa (W. var. *demissa*).
Arca Eastnori (not known elsewhere).
Orthoceras annulatum (W.).

"An examination of the fossils from this locality in the Collection of the Government Survey in Jermyn Street failed to afford us any trace of the Bala and true Caradoc fossils (quoted in Prof. Phillips's Memoir, p. 61), with the Wenlock types which we found; and as *Lingula attenuata* is marked there as abundant, and as we found abundant remains of an undescribed *Lingula*, certainly distinct from that species, it is just possible that the two references may be to the one object. It is possible also that the Caradoc *Orthis bilobata* may be a misprint for the Wenlock *Orthis biloba.*" (Professor M'Coy.)

So far as it goes, this list is, we think, decisive; and it seems to prove that Nos. 4 & 5 of the vertical section must be the very near equivalents of the May Hill series; and, therefore, true Upper Silurian or Wenlock sandstone†. On the scheme of Professor Phillips, the groups (to No. 5 inclusive) are called Caradoc. On the scheme of the "Silurian System," all the groups (as far as No. 6 inclusive) are called Caradoc. If we assume the old nomenclature, we are led into

* Memoir, p. 57.

† As we had not time to complete our section over Howler's Heath, and as Professor Phillips has given no separate list of fossils from that locality, we may subjoin the following list of Howler's Heath fossils, made from the drawers of the Geological Survey in Jermyn Street, to which a liberal access was granted:—

Petraia bina (W.).
Tentaculites ornatus (W.).
Encrinurus punctatus (W.).
Spirigerina reticularis (W.).
Pentamerus lens (May Hill).
Orthis elegantula (W.).
Leptagonia depressa (W.).
Leptæna lævigata (W.).
Strophomena pecten (W.).

conclusions which are at war with the fossil evidence, and are not proved by the evidence of the sections. But if we keep our nomenclature in reserve, and determine the true relations of the several groups, both by help of sections and of fossils, there is no real difficulty. Somewhere near the base of No. 4, among coarse and confused beds, we would (*at least provisionally*) draw our line of demarcation,—grouping Nos. 4, 5, & 6 with the true Silurian series, and cutting off from them all lower groups, which are, so far as we know them zoologically, rocks of a different series (*i. e.* Cambrian). In this view, the section of the South Malverns and the sections of May Hill are, we believe, in good accordance; and Nos. 4 and 5 become May Hill sandstone and conglomerate.

Sections on the N.W. flank of the Worcestershire Beacon.

It will be seen, by a glance at his very good ground plan (p. 60), and the Map appended to his Memoir, that Professor Phillips continues his highest Caradoc group of the South Malverns (No. 5 of the vertical section) along the western flank of the chain to a point north of the Worcestershire Beacon. From this view it follows inevitably, that the whole section, from the flank of the Worcestershire Beacon to the Woolhope limestone, must be through beds which are superior to the group under the obelisk of Eastnor Park. If this conclusion be admitted, it seems to follow, from the published lists, that *good groups* of Wenlock and Caradoc fossils *overlap one another in the Sections.* For example, Professor Phillips states that the Eastnor Park fossils belong to the lower fossil group of the Malvern sections (No. 4), and all the groups up to the Woolhope limestone are called Caradoc; yet we have seen that these Eastnor Park fossils form a true Wenlock group, not containing, so far as the fossils have been observed by ourselves, one characteristic Caradoc species. But in the list of fossils from the beds on the N.W. flank of the Worcestershire Beacon (which belong to No. 5 of the vertical section and therefore *overlie* the Eastnor Park group), he gives three or four species which are generally considered characteristic of the true Caradoc sandstone (Memoir, pp. 65 & 66); and in a subsequent page (p. 75), while discussing the boundary between the Wenlock and Caradoc groups, he states "that the older characters (both mineral and organic) reappear within the later deposits, and the later characters show themselves amidst the earlier deposits."

In my last Memoir I accepted the hypothesis of an overlap, on the strength of this evidence, though it made directly against myself. Professor M'Coy opposed it strenuously, on the evidence of the Woodwardian fossils which had been collected by myself during previous years; and our joint excursion was the result of this difference of opinion.

Our time was so limited that we were compelled to confine ourselves to one single section; and we naturally selected one exhibited "along a little stream which descends from the north-west end of the Worcestershire Beacon, where (as stated by Professor Phillips) the uppermost and lowermost beds of the Caradoc sandstone are

exposed, and both under interesting circumstances" (Memoir, p. 65): and he further states, "that these uppermost beds show a peculiar and unequivocal gradation or alternation from the lower to the upper Silurian series." The phænomena here noticed are also well described in the 'Silurian System,' where all the beds between the Syenites and the Woolhope limestone inclusive are considered as forming a true Caradoc group. The phænomena along the line of section are as follows:—(1.) Immediately under the public road is a series of beds dipping at an angle of about 60° towards the flank of the Worcestershire Beacon, and therefore *apparently* passing under the Syenite. They are in a reversed position. Their thickness is considerable, and in mineral structure they certainly might be brought into near comparison with some of the well-known calcareous and shelly sandstones of the true Caradoc groups of Horderley, Soudley, &c.

(2.) Next follows a short interval of obscure ground, where the rocks are partially covered; beyond which break out the uppermost beds of sandstone, graduating into the Woolhope limestone, exactly as stated by Professor Phillips, and in exact analogy with the corresponding beds of May Hill*.

Are the lower (and probably inverted) beds of this section true Caradoc sandstone? Professor Phillips's List of Fossils (pp. 65, 66) might seem to sanction an affirmative answer to this question; for in addition to about twenty species, which might be looked for in a good Wenlock group, he gives—

Atrypa hemisphærica,
Orthis testudinaria,
—— *flabellulum,*
Orthis virgata,
Trinucleus Caractaci,

which are generally considered good characteristic Caradoc fossils†. But if we adopt this conclusion, and also put down all the beds of this inverted section as one group (No. 5), it then must follow that a true characteristic Caradoc group (No. 5) may *overlie* a group with characteristic and *unmixed Wenlock species*‡ (No. 4). This admission would virtually affirm, not merely that the species of an upper group might descend into and be partially mixed with the species of a lower, but that a good upper group of fossils might overlap and descend beneath a lower group. Sooner than (in the case before us) adopt so improbable an interpretation of the facts, we should appeal to the broken discontinuous sections, and unhesitatingly affirm that the upper and lower portions of the beds, above described, belonged to two separate groups; the beds near the Syenite having been brought

* Professor Phillips, whose sections we have constantly relied upon, without any doubt of their accuracy, states that the horizontal length of this section from the Syenite to the Woolhope group is about 500 feet.

† Respecting these species, see Professor M'Coy's observations appended to the list of fossils from this locality, p. 227. All our specimens were found on the north side of the rivulet, and we missed the purple sandstone (Phillips, p. 65) on the south side. We did, however, trace our section close up to the Syenite.

‡ We have already shown that the fossils of the Eastnor Park group (No. 4) are either new, or such as are found in true Wenlock beds. They are, therefore, a good Wenlock group.

up from beneath the purple sandstones and conglomerates of Eastnor Park (No. 4).

So far as our own evidence goes, we are not, however, driven to this or any other new hypothesis. We believe the beds of the section to belong to one group (No. 5), (exactly as Professor Phillips interprets them,) and that they do represent the shelly sandstones, &c. which underlie the Woolhope beds of May Hill. About the upper beds of the section there seems to be no doubt. The lower beds may contain a very few species of fossils, generally considered characteristic of the Caradoc sandstone; but no such species fell under our notice; nor do they appear to exist in the Malvern drawers of the Museum of Economic Geology.

The following is our list of fossils from the inverted beds on the N.E. flank of the Worcestershire Beacon:—

Petraia (unnamed, same as at May Hill).
Favosites multipora, W.
Palæopora petaliformis, W.
Halysites catenulatus, W.
Tentaculites ornatus, W.
Pentamerus linguiferus, W. (including *P. undatus*).
—— *lens* (same as at May Hill).
Orthis biloba, W.
—— *elegantula*, W.
Strophomena pecten, W.
Spirigerina reticularis, W.
—— *marginalis*, W. (*Terebratula imbricata*, Sil. Syst.)
Spirifera cyrtæna, W.
Hemithyris lacunosa, W.

"As in the former lists, the species known in other undoubted Wenlock localities are marked W. On referring to Mr. Salter for information on the *Orthis testudinaria*, *Orthis flabellulum*, and *Trinucleus Caractaci*—good Caradoc or Bala types quoted from this spot in the 'Memoir of the Geological Survey,' p. 66,—he informs us that there is no trace in the collections of the first nor last, and that he doubts the existence of *O. flabellulum*, referring the single valve which they have, like it, to the *O. virgata*,—the same variety as found at May Hill. This locality fixes the species, in our mind, for the shell found at May Hill is so like *O. flabellulum*, that it was described by that excellent authority Mr. Davidson as *O. flabellulum from the Wenlock limestone* of Walsal; but subsequently distinguished as a perfectly distinct species by him and M. de Verneuil under the name *O. Davidsoni*, so that the species is an exclusively Wenlock one." (Prof. M'Coy.)

Hence we conclude that the sandstones of the Malverns, like those of May Hill, are not true Caradoc, but belong to an intermediate group, which, in the words of Professor Phillips, "were deposited in an ocean filled with the life of the Wenlock period." I have thought it better to define these groups by the name *May Hill sandstones* rather than *Malvern sandstones*; because the true base of the latter may be regarded as in some degree doubtful; and still more, because of the Black shales (No. 2), and the Hollybush sandstone (No. 1), which appear to form the base of the whole Malvern series; and for reasons above stated, I would place the two last-named groups (Nos. 1 and 2), *provisionally*, as true Caradoc groups, till we have fuller information respecting their fossils.

Horderley Sections, &c.

The section along the Onny has so often been described, that no gleanings, it might be thought, could be gained from it. But having during a former year traced what I regarded as true Caradoc species considerably within the limits of the Wenlock shale as coloured in the Government Survey; and having found, through the help of my friend Mr. Duppa, of Cheney Longville, the *Trinucleus Caractaci* in great abundance within less than 100 yards of Stretford Bridge, I was very anxious to obtain Professor M'Coy's help in determining a more correct boundary between the contiguous shales of the Caradoc and Wenlock groups. On the banks of the Onny I met, however, with a great disappointment, as all the critical beds, in consequence of the previous rains, were under water; but I hope before long to be enabled, through the kindness of Mr. Duppa, to exhibit to the Society a good series of the fossils from the shales immediately above Stretford Bridge. In another respect I was more fortunate; for in making a traverse along the Bishop's Castle road from Horderley to the spur that descends from the Longmynd, Professor M'Coy discovered a few species of Caradoc fossils in a part of the country which is coloured Wenlock shale in the Map of the Survey. We therefore concluded, that here, as along the Onny, a thick mass of Caradoc shale overlies the Pentamerus or Hollies limestone*, and that the colour of the Wenlock shale must be considerably contracted. The same remark makes it also probable, that the dislocated shales on the road from Horderley to Church Stretton (coloured as Llandeilo in the Map of the Survey) belong to the Caradoc shales rather than to the lower portions of the Bala group. This is however a minute, and perhaps doubtful point, which I wish not to discuss.

The order of succession, in the country here under notice, appears therefore to be as follows:—(1.) Caradoc sandstone, &c., ending nearly with the Pentamerus or Hollies limestone; (2.) Caradoc shale; (3.) Wenlock shale; (4.) Wenlock limestone, &c. Where then are we to place the May Hill beds? We can only reply, that they do not appear in the section. They *may* have thinned off so as not to have left their representatives in this portion of the deposits: or they *may* have been covered up by a slight discordancy of position, which has brought the Wenlock shales into contact with Caradoc rocks that are undoubtedly older than the sandstones of May Hill.

Whatever hypothesis we adopt, there is no greater difficulty presented by the section here under notice, than there is in sections, formerly described by myself, through the country on the north-eastern flank of the Berwyn chain. For example, commencing in the valley of the Ceiriog and taking a north and south section across the valley of the Dee, near Llangollen, we have a part of the upper Bala group immediately overlaid by beds of the Wenlock age, without any apparent want of conformity or true continuity. Yet it is evident, on an extended comparison with the neighbouring groups,

* The limestone alluded to in the text contains, as is well known, the *Pentamerus lævis* and *Pentamerus oblongus* in very great abundance.

that a large series of beds must be interpolated to make this Ceiriog section complete*.

Though the representatives of the May Hill grits have disappeared from the Horderley sections, yet farther towards the north (for example, along the north-western part of the Berwyn chain, and in the long range north of the Holyhead road, which is now coloured as Caradoc in the Government Map), these grits break out in great force in their proper place, and with their characteristic fossils. I adhere, now, to the opinion adopted on the spot (in 1842 and 1843) by Mr. Salter and myself, and believe that the sandstones and conglomerates, which on the line of the Holyhead road form the base of the Denbigh flags, are Upper or true Silurian, and the equivalents of the May Hill sandstone; and that the same rocks are not the equivalents of the sandstones of Horderley and Caer Caradoc, as they are represented (under one gamboge colour) in the Map of the Survey; the true Caradoc sandstone being but an example of an upper shelly sandstone near the top of the great Bala group, and therefore a true Cambrian rock. I believe, therefore, that the opinion formed by Mr. Salter and myself in 1842 and 1843 was right; and that, in this part of the series, the colours on the Map of the Survey require some modification. Without, however, dwelling on phænomena which I had no opportunity of revisiting during the past summer, I think I have shown sufficient positive evidence for some considerable corrections or changes of colour in those parts of the Government Survey which relate to the rocks described in the previous sections. And before leaving this subject, I may add my present conviction, that the Coniston grits will turn out to be the representatives of the May Hill, rather than of the Caradoc, sandstone.

Admitting the previous statements, some not unimportant conclusions seem inevitably to follow from them:—

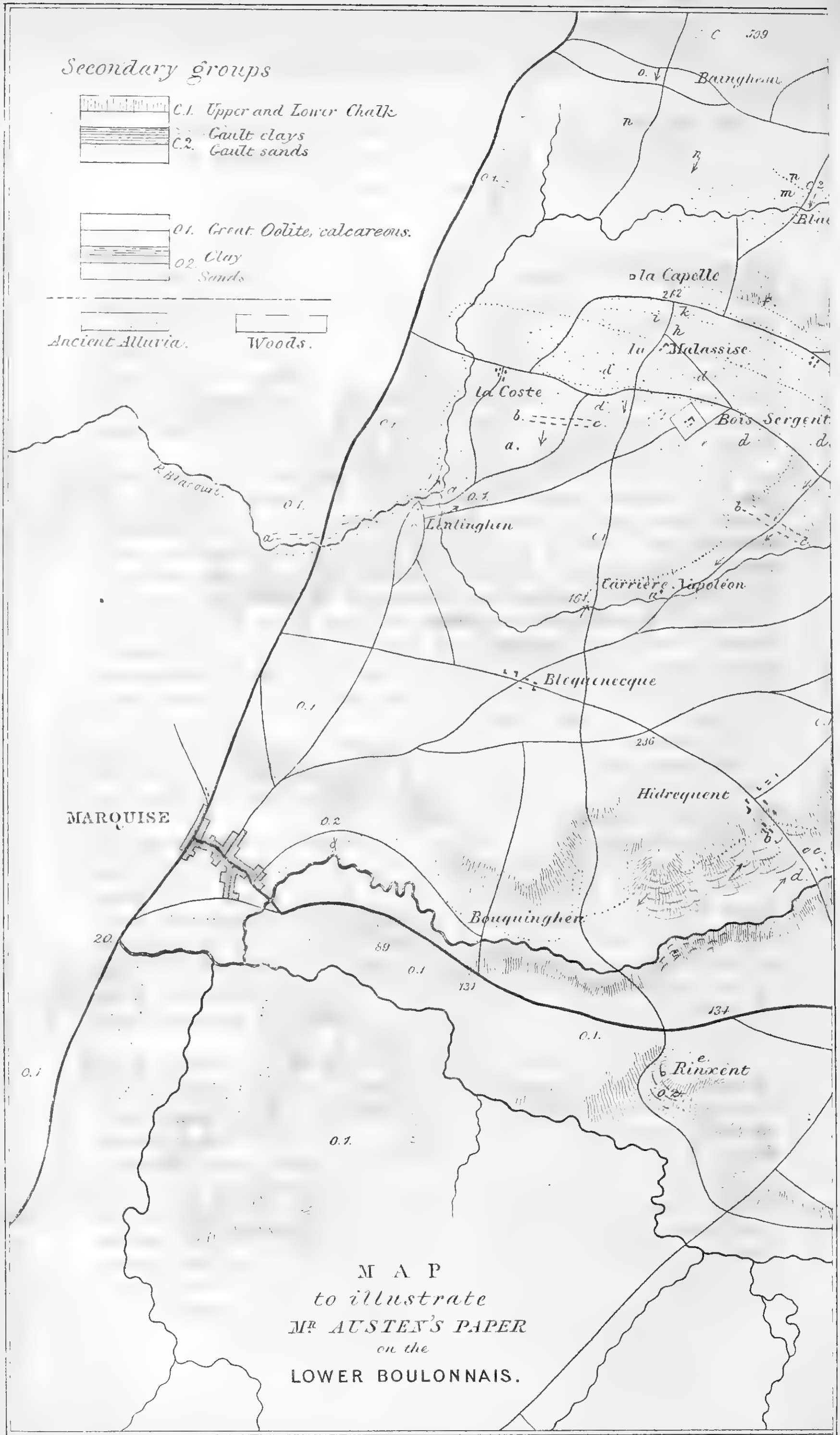
(1.) In the Second Fasciculus of the description of the Palæozoic fossils of the Cambridge Museum, there is given an enumeration of all the species below the Old-red-sandstone, with the per-centage of species supposed to be common to the Cambrian and Silurian rocks, all the new species being determined on the authority of Professor M'Coy, and all the other species having had the sanction of his careful examination and description. Now, in making out this per-centage, I had accepted the interpretation of the Government Survey, so far as regarded their Caradoc sandstone; and I had consequently counted as *Lower Silurian* in their nomenclature (or as *Cambrian* in my own nomenclature), many rocks (such as the Malvern and May Hill sandstone, &c.) which I now believe to be true, or Upper, Silurian. Hence, in my present view, the per-centage of species, which are common to the true Cambrian and true Silurian rocks, must be considerably reduced; and we shall now have no real difficulty (even if we adopt the word *System*) in affirming that, below the Old-red-sandstone, we have in Britain, at least, two palæontological systems, by whatever names it may hereafter be thought right to designate them.

* See Quart. Journ. Geol. Soc. vol. i. p. 17.

(2.) According to this view of the subject, the older Palæozoic rocks of Britain will be brought into a good accordance with the Palæozoic sequence in Bohemia and North America; and such good observers as Hall and Barrande will be relieved from a very great difficulty in comparing their magnificent older Faunas with that of England and Wales. It may be true (as indicated in the works of Professor Hall) that the separation betwen the upper and lower divisions of the older Palæozoic rocks of America is more sharply defined than in England; and we know M. Barrande allows hardly any interchange of species between his upper and lower divisions of the older Bohemian rocks. Hence these two authors may have been led to suppose that the development of the older Palæozoic rocks in England was imperfect or anomalous. I believe, however, that this Paper will help to clear up any such misconception; for it exposes one unexpected source of confusion, and helps us to separate our Cambrian and Silurian groups more completely than they were ever separated before*.

(3.) There is so wide a distinction between the collective organic types of the Primary (or palæozoic) and Secondary periods, that we may conveniently regard them as exhibitions of two distinct *systemata naturæ*. But the same cannot be said of the great subdivisions, such as the Carboniferous, Devonian, and Silurian series, &c. These subdivisions are sometimes ill-defined, and have certain species in common. The Carboniferous fauna at its inferior limit may be partially confounded with the Devonian; and in like manner the Devonian with the upper portion of the Silurian, and the Silurian with the upper portion of the Cambrian. Hence it might be better to use the word *Series* rather than *System*, as applied to these palæozoic subdivisions. It is, indeed, a matter of comparatively small moment by what names they are described, provided our conventional terms be well-defined and understood; but this we may, I think, venture to affirm—that if we adopt the word 'system' in the more limited sense in which it has during late years passed current in the Geological Society, the Silurian and Cambrian systems are as well separated, both physically and palæontologically, as any of the so-called systems of the great Palæozoic series.

* The Palæontological separation between the Cambrian and Silurian rocks is, I believe, still more complete in Westmoreland and Cumberland than it is in Wales and the counties adjacent to it. This will be evident to any one who will take the trouble of analysing the lists given in the 2nd Fasciculus of the Cambridge fossils above referred to. A less perfect list of fossils (collected in the northern counties) was given by Mr. Salter as an appendix to a second edition of Four Letters by myself on the Geology of the Lake District, published in 1846. His first list contains more than 120 species derived from the series of beds above the Coniston limestone group. His second list, from the Coniston group, contains about seventy species. *Lamellibranchiata* abound in the first list, and are not found in the second; and very few species (not more than two or three) are common to his two lists.



MAP
to illustrate
Mr AUSTEN'S PAPER
on the
LOWER BOULONNAIS.

C. Achilles. lith.

On the Series *of* Upper Palæozoic Groups *in the* Boulonnais.

By Robert A. C. Austen, Esq., F.R.S., Sec.G.S.

[Read March 23, 1853*.]

[Plate X.]

In May 1852 I accompanied Prof. Edward Forbes, Mr. Prestwich, and Mr. Morris in a geological excursion into the Boulonnais and part of Belgium: the examination which we were enabled to make of the district about Marquise, though brief, was sufficient to satisfy us that the Palæozoic group there had not been described with sufficient precision and detail. I therefore visited it again in the autumn of the same year, and on that occasion I was joined for several days by Mr. Daniel Sharpe.

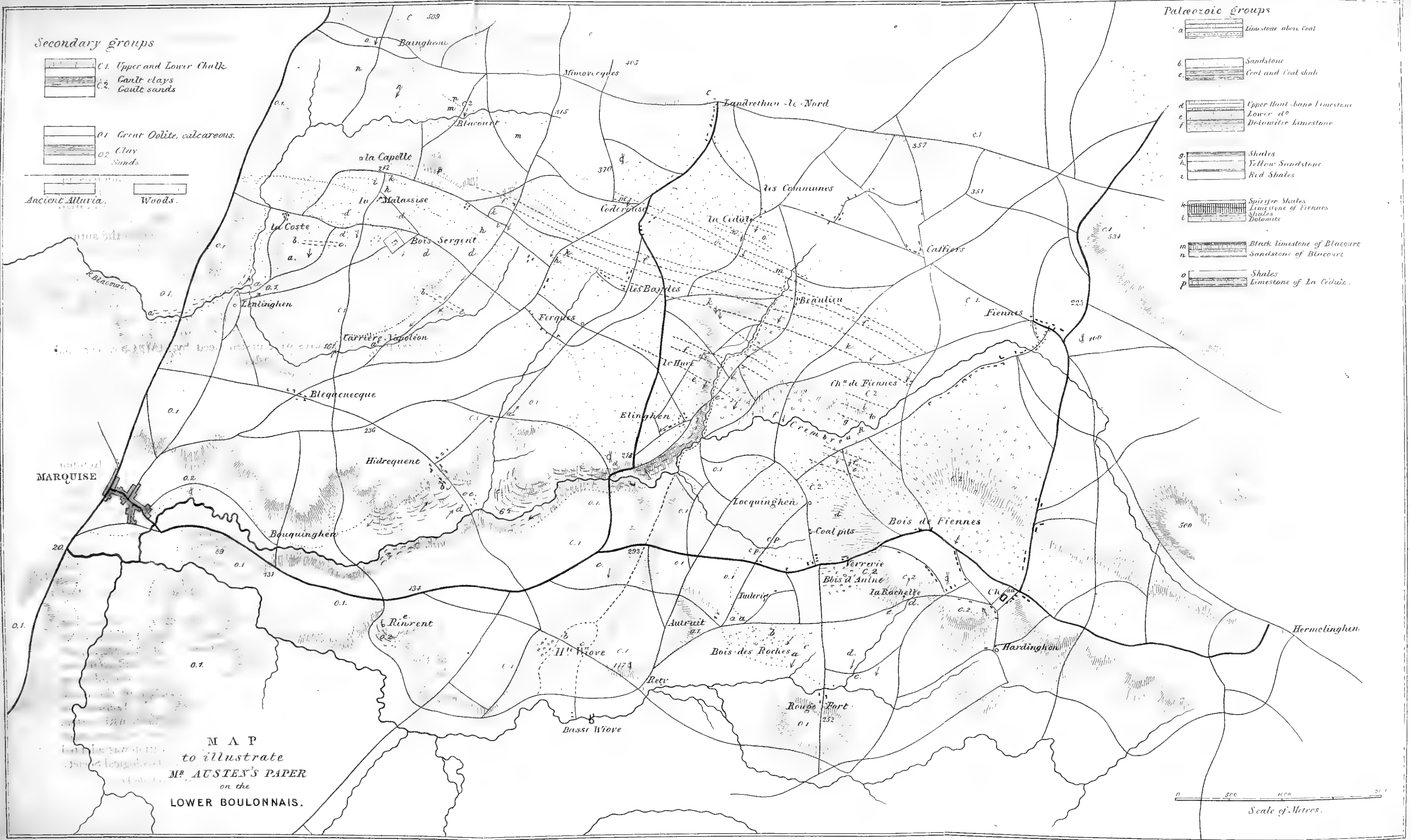
The Lower Boulonnais is a district of the province of Artois, which has for its natural limits the escarpments of the chalk formation: its breadth from north to south, as from Wissant to Verlinctun, is about fourteen miles; and its length, from Boulogne to Lottinghen, about twelve. This district has been of interest to the English geologist, since its physical features were first noticed by MM. Conybeare and Phillips, as it constitutes the eastern extension of our Wealden denudation. In the extreme north-east angle of this area, a little beyond the village of Marquise, and at the very base of the chalk escarpment, there is a very limited tract, which is the subject of the present communication. See Map, Plate X.

The palæozoic rocks of the Boulonnais were described by M. Rozet in his general memoir on that district, and they occupied much of the attention of the French and English geologists during the Réunion Extraordinaire at that place in 1839.

M. Rozet attempted to place the Boulogne series in accordance with the popular systematic arrangements of the carboniferous rocks of England, and this led him into error. The account of the Boulogne Meeting, contained in the Bulletin of the French Geol. Soc. vol. ii. 1840, must be separated into two portions of very unequal authority—the one being that containing the views and observations of the geologists then present—the other a communication from M. Souich, a resident mining engineer, and full of accurate statements respecting the structure of the district.

In 1838 M. de Verneuil published an account of a section from Marquise to Landrethun†, in which the lower subdivisions of the Palæozoic series were identified as the equivalents of the several parts of the "Silurian System," and this view was adopted and confirmed by Sir R. Murchison when at the Boulogne Meeting in the following year. At the close of that Meeting a small collection of the fossils of the Ferques and Fiennes limestones was sent to Mr. Lonsdale for examination, and he at once recognized their agreement with certain forms from South Devon, which in the previous year had been taken as the types of a "Devonian System." This rectification was adopted by Sir R. Murchison in a paper read to the French Geological Society

* *Vide supra*, p. 115. † Bull. Soc. Géol. de Fr.



C. Achilles, lith.

in 1840, in which there will be found a theoretical section and a new systematic division of the Boulogne Palæozoic series into Carboniferous, Devonian, and Silurian.

More recently M. Delanoue * has proposed to arrange the Boulonnais series according to M. Dumont's Belgian system: the lowest beds of this locality are identified with the "Terrain Rhénan," and which is considered to be "Silurian."

§ 1. *Sequence of the Palæozoic Rocks of the Boulonnais in descending order.*

First Division.

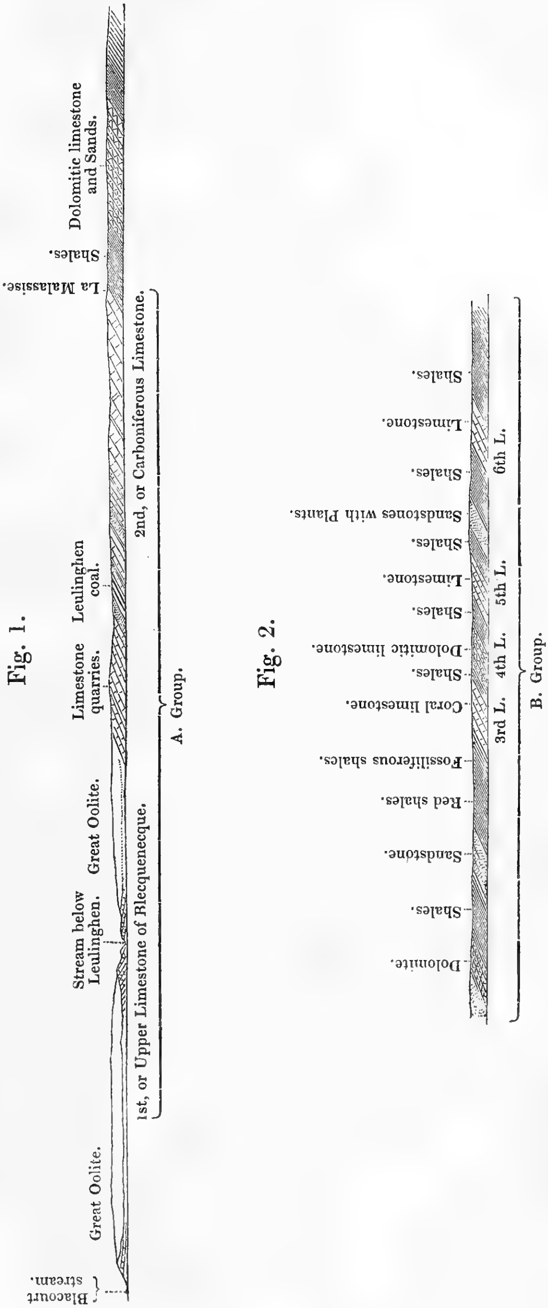
Limestones above and below the Coal.—At a spot where the high road from Marquise to Calais crosses the Blacourt stream, a considerable mass of Great Oolite is seen resting on a dark thick-bedded crystalline limestone; below the bridge the beds are nearly horizontal; they can be traced along the course of the stream upwards, but beneath the hamlet of Leulinghen, and on the right bank of the stream, the limestone has a dip of 25° N.E.; the lower thick beds are here surmounted by thin and fragmentary ones. Across the stream, and on the ascent to the farm of La Coste, like beds are surmounted by the lowest stratum of the oolite, containing numerous small *Ostreæ*. A little above this the table-land again presents a bare limestone surface, over which are several quarries and the spoil of the old coal-works of Leulinghen. The southernmost portion of this limestone may be seen in two places to dip 25° S.

This limestone is succeeded on the surface by a band of shales and sandstones, and subordinate to which are the seams on which the old coal-works of Leulinghen were established. The strike of the outcrop of these coal-measures corresponds with that of the limestone immediately adjacent. The works are now abandoned, but I was informed, by one who was well acquainted with the mines, that the beds sloped away at a high angle to the south and were much disturbed. The breadth of the outcrop of the coal-measure series is not more than 100 feet.

Immediately to the north of the coal-measure band there is an extensive tabular surface of limestone, of which the east and west strike is well-defined, the dip being south: these limestones therefore underlie the coal-measures. These lower limestones extend northerly and easterly towards La Malassise and Bois Sergeant; in these directions they are overlaid by thick accumulations of gravel-sand, brick-earth, and pipe-clay, with much vegetable matter, and which have to be worked through for the iron-ore beneath †. These limestones are much fractured, but dip invariably to the south on the side towards La Coste, and to the south-west about Bois Sergeant; this change of strike is caused by a fault which is clearly indicated on the present surface: the dip is variable, being never less than 30°, and in places as much as 42°.

* Bull. Soc. Géol. de Fr. 1853.

† The whole of this series of accumulations in the Boulonnais is peculiarly deserving of attention.



Figs. 1 & 2.—*Sections of the Upper Palæozoic Limestones, &c. in the Boulonnais.*

Owing to the surface accumulations, the lower limit of this second limestone group is not very clearly defined about Malassise; yet the superficial breadth and the high angle to be observed throughout show that the three groups here described form a series of considerable vertical dimensions.

A little to the south of the line above noticed, another section may be taken across the same series. At the westernmost of what are known as the Napoleon Quarries, near Blecquenecque, where the road crosses the line of an occasional watercourse, the beds of limestone are seen to dip E.N.E., but are much fractured. At a second quarry they dip E., subsequently they present a mere undulation, and finally, where they emerge clear of the Great Oolite, they slope rapidly to the S.W., the basset edges serving to mark the strike of the beds very distinctly.

The old coal-works of Ferques, which were established on the outcrop of the coal-seams, are immediately on the N.E. of these limestones, and, as in the former section, the coal-measure group is succeeded by the lower limestones, having a S.W. dip of 30°. In this section the outcrop of the coal-measures between the upper and lower limestones is more distinct than in the other, and it is also shown that the Napoleon marble is a subordinate band in the upper limestone.

It is clear from these two sections that the coal-measures of Ferques and Leulinghen are intermediate between two great limestone groups, to which they form a very natural systematic division. M. du Souich gives the true position of the Boulogne coal in several passages of his memoir *, yet I found that his views had not been readily adopted even by mining engineers, and that some were disposed to consider it as occupying a great fault or fissure. The main fact in favour of this view is the high angle of the coal-seams, which is alleged to be greater than that of the limestones, a consideration to which the practical geologist will not attach much importance: wherever thick masses of strata variously composed have been much disturbed, the more yielding beds, such as clays and shales, invariably show a greater amount of dislocation than the thick compact masses which may include them; and such is the case in this instance.

The lower limestone group may be followed from La Coste by Bois Sergeant, Ferques to Elinghen, where, as N.E. of the church and in a large quarry overlooking the stream, it dips to the S.W. The stream here runs along a line of fault, on the west of which there is an upcast of the limestones: the inclination of the beds veers round to N. and E.N.E., and they rise gradually till at Haut-banc the limestone attains an elevation of 280 feet.

The upper or "little quarries" at Haut-banc consist of thin-bedded limestone and of sandy magnesian limestones: in this portion a species of *Lithostrotion* is very abundant. The great quarries present a vertical thickness of 60 feet, consisting of beds which underlie the above. This portion has an upper series of thin strata with occasional

* Sur la Course Géologique du 11 Sept. 1839; Bull. de la Soc. Géol. de Fr. t. x.

partings of red compact shale, and which is separated by a very marked horizontal line from a lower one of thick-bedded compact limestone: this sudden break or change in the condition of the Haut-banc limestone has been noticed by M. Rozet. The lowest beds of this group are quarried opposite the Château des Barreaux; they are somewhat darker than the middle portion, and admit of being worked for ornamental and useful purposes.

Organic remains are not common, or at least obviously so, throughout either of the limestone groups here noticed; yet in beds of the Napoleon marble, and which has usually been described as altogether unfossiliferous, it will be found that where the limestone has been decomposed at the junction with the sands of the oolite, every flake struck off in the plane of the bedding presents beautiful surfaces of *Chonetes* and *Strophomena*, of which it is not possible to detect a trace in the more crystalline mass. As an exception to the general rule respecting the indistinctness of the fossils of the upper limestone, there is a remarkable bed, about 2 feet thick, subordinate to the band of Napoleon marble, which is entirely composed of *Terebratula elongata* and one or two other forms.

The following list of species from the upper limestones, as well as every other contained in this memoir, has been drawn up by Mr. D. Sharpe: it will be readily seen to what extent he has added to our knowledge of the distribution of forms, and thereby given a value to the present communication which it would not otherwise have had:—

Terebratula elongata, *Schloth.*
Spirifer glaber.
Productus Martini.
—— auritus.
—— undatus.
—— scabriculus.
Chonetes papilionaceus, *Phillips.*
Strophomena crenistria, *Phillips.*
Euomphalus pentangulatus.
Natica antiqua, *Goldf.*
Loxonema sulculosa.

The limestone of Haut-banc contains—

Lithostrotion.
Productus auritus.
—— antiquatus.
Productus comoides.
Terebratula hastata.

Below the hamlet of Basse Normandie there is another considerable mass of limestone, on either side of the stream of which neither the age nor relations were ascertained by the geologists at the Boulogne Meeting. At its eastern limit this limestone dips E., and does so for a considerable portion of its mass; it then arches over, and on the side near the road from Blecquenecque to Rinxent dips W. or S.W. In this portion dolomitic beds like those of the upper quarries of Haut-banc occur; the uppermost beds in this direction consist of compact limestone with seams of chert, apparently passing into shales. I therefore consider it as belonging to the Haut-banc group of limestone.

In the Hardinghen district the carboniferous group is much less clearly exhibited. On the N. the Haut-banc limestone may be seen for a short space in the Bois de Fiennes striking N.W. & S.E. nearly, and dipping S.W.; it then passes beneath the coal-field of Locquinghen. The limestone which occurs immediately at the back of the

Verrerie, I was assured by M. Buchet, was above the coal-measures; it is inconsiderable in extent and thickness, and represents the lower portion only of the Blecquenecque limestone.

S.W. of the Bois d'Aulne the lower limestone rises from beneath the coal-basin of Locquinghen; it then apparently arches over, as the bed of the watercourse from near La Rochette downwards shows that the superficial covering rests on limestone. A little to the E. of the road from Locquinghen to Rouge-fort there is an old quarry of a black limestone, and which at one time was much sought for as an ornamental marble; the quarry presents fine beds of compact rock, above which are from 8 to 10 feet of flagstone bands, equally black; the uppermost bands alternate with two seams of splintery chert, and are overlaid by fine shales; these beds would therefore seem to correspond with those noticed on the road from Rinxent to Blecquenecque.

The dip of these black limestones is to the S.W. at a considerable angle: a little to the E. of the quarry the basset edges of another limestone may be seen in projecting masses through the cultivated ground, and which presents a remarkable contrast in colour, being white or nearly so; it contains large *Producti* in great abundance (*P. auritus, P. giganteus*); it immediately underlies the black beds.

The fossils of these uppermost beds of the Haut-banc group are—

Productus Martini (semireticulatus, *Martin*).
—— undatus, *Defrance.*
—— antiquatus.
—— plicatilis.
—— longispinus (Flemingii, *Sow.*).
Productus fimbriatus.
Spirifer lineatus.
—— glaber.
—— duplicosta.
—— bisulcatus, *Sow.*
Turbinolia fungites?

Coal-measures.—In the strict order of sequence, this group should have been taken next after the upper limestones of Leulinghen and Blecquenecque, but in a district such as that here described, where, owing to the extent of superficial covering, the succession cannot be followed out at one place, but is to be deduced from a comparison of many sections, the order here taken is most convenient.

Neither the thickness, nor order of sequence of the series which includes the coal-seams, can be determined near Leulinghen and Ferques. The whole of the carboniferous group, as already seen, is highly inclined, and the upper edges have, at some subsequent time to this movement, been planed down to a uniform tabular surface; at these places, however, the refuse heaps of the old workings sufficiently indicate the character of the beds in which the coal is included. A section may be compiled out of a series of scattered observations to be made at the eastern extremity of the Bois des Roches. First, along the line of the watercourse from the black limestone quarry, the lowest coal-shales may be traced, and distinctly overlying the limestone; above these are the sandstone bands, followed by a considerable thickness of light-brown gritty and very micaceous sandstone, to be seen in the road section leading towards Rouge-fort; these all dip S.W. till they are concealed by the Inferior Oolite, which halfway down the descent to the stream abuts against them horizontally. The strike of these beds carries them in a N.W. course towards the

Bois des Roches, where at one time they were worked for coal. In the Bois des Roches, the whole carboniferous series is highly inclined, the basset edges of the limestones projecting in great weathered masses; and though, from the thick growth of wood, it is difficult to get at the structure of the mass, it is evident near the old shaft of Autruit that the coal-measures are in an intermediate position: at no other place do we find so great a thickness of the upper limestone. As the sandstones of this place have been confounded by M. Rozet with some others of a very different age, it may be as well to state that these contain numerous impressions of Calamites and Ferns which the sands above the Fiennes limestone do not.

The high road due E. from Marquise is along a platform of oolite which is of inconsiderable thickness. A well sunk at the back of the great iron-works at Bouquinghen, reached sandstones and shales with impressions of plants, belonging probably to the coal-measures. Further on the oolite is seen resting on limestone as at Rinxent. At the turn off by Le Gentrie to Wiove, there is a slight descent into a valley, which runs S.W. N.E., and which, from the dip of the oolite beds in the plateau, is clearly a valley of fracture; in this are two low rounded hills of coal-measure shales and sandstones; these beds overlie the Haut-banc limestone, which extends from the Château des Barreaux to beyond the road to Hardinghen.

I would also refer to this series the group of strata which attracted the attention of the geologists of the Boulogne Meeting, and is to be seen on the ascent to Hedriquand from the river: the local mining engineers were disposed to place it above the Haut-banc limestone, whilst the palæontologists present affirmed that the fossils were characteristically Silurian. The group is exposed for a thickness of 80 feet, and consists of alternations of dark shales with bands of greenish sandstone, surmounted by shales only, and as such corresponds exactly with the lowest portion of the Hardinghen coal group. The sandstone bands contain casts of *Productæ* in abundance, and it must therefore be considered as the extension of the band of Leulinghen and Ferques. The relation of this group to the limestone exposed in the sides of the valley, rather lower down, is clear: when first seen at the level of the stream on the side towards Basse Normandie, it has a N.E. dip, which carries it beneath the shales and sandstones, and the reasons for considering this limestone to belong to the lower or Haut-banc group have already been given.

The vertical thickness of the several component parts of the coal-measure series is not uniform even on the limited area here described; the sandstone bands thin out amidst the shales; lenticular seams of pure limestone also are intercalated with the lower portion, and the coal-beds have been found to thin out. The Hardinghen works would show that there were about five distinct levels at which the formation of coal took place; the associated shales contain in abundance the remains of Ferns, showing that the vegetation was terrestrial, whilst the intervening sedimentary beds indicate the conditions met with in bays and other protected portions of a sea-board; and we may hence

also infer that certain forms of *Productus* which these beds contain were inhabitants of the marginal zone. Though this coal group may not exceed 150 feet in thickness, the fine lines of deposition of the component parts indicate very slow accumulation: the conditions are those of the alternate elevation and depression of a shelving coast-line, which at one time formed a subaërial surface covered with vegetation, and at another a submerged one, into the waters of which the fallen fern-fronds of some district not far distant were abundantly conveyed. As the strongest seam at Hardinghen exceeds 3 feet, which would imply an original growth of peat of nearly three times that thickness, the subaërial intervals were probably of very long duration. I am unable at present to assign any definite thickness to the uppermost limestone; it is greatly reduced by denudation about Leulinghen, and it cannot be readily measured in the Bois des Roches, where it is most complete. The coal-measures are not less than 150 feet thick, but are unequal, and this I have no doubt is due, not to very unequal accumulation, but to the removal of a portion of the series in places before its subsidence into those depths at which the upper limestone series was accumulated.

At Haut-banc the limestone is 210 feet thick, but the upper surface has been deeply denuded, as may be seen in any of the open workings for iron-ore, in the plateau of Elinghen; if to this be added the series seen at the black limestone quarry (p. 236), or that near Locquinghen, we may estimate it safely as exceeding 200 feet.

The course of the streamlet from Beaulieu (which is a line of fault) presents the only clear section of the beds immediately beneath the Haut-banc limestone.

a. First in descending order are shaly limestones and pure argillaceous shales, as beneath the limestone of Elinghen.

b. Next below these is a very considerable mass of stratified dolomitic sandy limestone, the calcareous portions at times being small; the rock is of a dark cindery-brown colour, and harsh to the touch. It contains in parts fragmentary fossil remains, and the disjointed stems and other parts of Crinoidea in abundance. This band seems to belong to the zone of finest drifted sand mixing with calcareous sediment, and it presents external characters which render its recognition easy wherever it is exposed. It is seen to the N. of the windmill of Le Hure, but is soon concealed by surface detritus; in a N.W. direction it can be detected at the back of the farm of La Malassise. To the S.E. of Le Hure, it comes out in the Crembreux stream, and crosses the Bois de Fiennes, where it may be seen passing beneath the Haut-banc limestone, as in the road from Fiennes to Locquinghen; but for this dolomitic band it would be very difficult to fix the age of the limestone at this place, and which passes beneath the coal-basin of Fiennes.

This dolomitic band is the lowest of the groups of strata which compose the upper division of the Boulonnais series, or that which answers to the "Mountain Limestone" of Belgium and the British Islands.

Second Division.

Yellow Sandstone Group.

1. A band of shale, but of which it is difficult to ascertain the thickness, may be seen next beneath the mountain-limestone-dolomite, near Le Hure, as also about Ferques. I was unable to observe any break of continuity with the beds above; it would seem as if the progress of accumulation passed uninteruptedly on, changing gradually from argillaceous mud to calcareous mud, yet so as to make it impossible to draw any natural divisional line; yet some such line is rendered necessary from the change of animal forms, which becomes very marked at about this part of the series.

2. As far as my own observations went, this band of argillaceous shale is non-fossiliferous, but immediately beneath it is a group of strata characterized by a subordinate band of sandstones, which may be seen in the road-section from Landrethun to Ferques; at this place bands from a few inches to a foot in thickness are repeated at wide intervals, and so pass into the shale band placed at the head of this division. In this section the superficial breadth of the sandstone series is 22 yards, with a S.W. dip of 20°, which gives a thickness of about 25 feet.

This sandstone is again seen in a lane-section E. of Ferques, as also on the left of Beaulieu stream, opposite Le Hure; thence it crosses the Bois de Beaulieu, and runs out on the Crembreux stream, where its whole thickness is exhibited in a large quarry. The sequence of the beds is just such as at Ferques.

This sandstone is fine-grained and exceedingly micaceous; it is of a beautiful clear yellow, occasionally in the lower seams acquiring a faint red tinge; it is used for a variety of purposes, such as for floor-paving, feeding-troughs and window-mullions. The surfaces of the partings of the beds present beautiful impressions of Fucoids.

This sandstone is the Grès à Unio of M. Rozet, from a supposed resemblance of a shell it contains with the *Unio subconstrictus* of Sowerby; he considered it to be of the same age as the Millstone grit of the English coal-measure series; it was the Psammite de Ludlow of the Boulogne Meeting. It has been confounded with the sandstones of the coal-measures, as by MM. Dufrénoy and Elie de Beaumont (Explication de la Carte Géol. de France, vol. i. p. 783).

The fossil remains occur only in the condition of casts, but we were enabled to procure such specimens as leave no doubt as to the species to which they are referable; they are—*Cucullæa Hardingii, C. trapezium, C.? amygdalina*. There are two species of *Cypricardia*, and a *Bellerophon*, which has been quoted as *B. bilobatus*.

The forms of *Cucullæa* here noticed are of much interest, inasmuch as, together with the *Cypricardia*, they occur in a very similar sandstone in the Devonshire series of Baggy Point and Marwood, and range downwards from that zone, wherever sands occur, as low as the Ilfracombe group; they thus enable us to place this portion of the Boulogne series in correspondence with our own.

3. Bright red shales and clays underlie the sandstone, as may be seen in the quarry near the Château de Fiennes; and this band may be traced across the district at intervals, by the colour it imparts to the surface soil, as near La Malassise, and west of Ferques, where the iron ore is raised.

These red shales are succeeded or pass into others of a dark grey tint: the superficial breadth of this argillaceous group is about 170 yards, which with a mean dip of 20° gives it a thickness of about 180 feet.

Limestone of Ferques and Fiennes.

Strictly speaking it is the Haut-banc limestone which is nearest to the village of Ferques; the band now in question passes it at some distance on the north-east. This limestone is not separated by any very marked line from the group next above it; some of the characteristic shells of this second division of the Boulogne series (*Terebratula, Spirifer*) are most abundant in the shales, which overlie the limestone, and belong to the higher group; with these are isolated masses of coral in lenticular masses, representing the gradual cessation of conditions favourable to their increase.

The pure limestones are very distinctly stratified throughout; the upper portion is thin-bedded, and the intervals would seem to indicate periods of time when accumulation ceased; the duration of these may be estimated, as it is mostly in the upper portions of each of these beds that these large coral masses, with perfect terminal surfaces, are met with, and which are so characteristic of this band. The middle portion of the band presents one or two distinct zones of Spirifers: the lower beds are thicker, darker, and afford ornamental marbles, besides being worked into pavement slabs. This limestone band is the only portion of the series which can be traced continuously across the area of the older rocks; it is also more extensively quarried than any other: near La Malassise it ranges for a short space rather E. and W. of its usual strike, thence it runs nearly N.W. S.E. as far as the fault along the Beaulieu stream; it crosses the Bois de Beaulieu W. 10° N. and runs out in the Crembreux stream at the Château de Fiennes.

In its range from west to east the inclination of this band presents at intervals 8°, 10°, 20°, 25°, and lastly at the Crembreux stream as much as 35°.

The abundance of the fossil forms preserved in this band places it in striking contrast with the higher limestones, but they are not equally distributed throughout—the upper portion is by far the richest.

The following list of species contains only the result of Mr. Sharpe's examination of what we ourselves collected; in the general list there will be found others quoted on the authority of competent observers, but even that gives a very imperfect notion of the richness of the fauna of the Fiennes band. The collection of M. Bouchart of Boulogne contains numerous forms which we were not able to meet with, and of which it is understood that he proposes to publish a

description. I noticed forms of Crinoids, and of bivalve, gasteropod, and cephalopod shells such as occur in our Devonshire series; with these were also other forms, such as *Tentaculites*, *Conularia*, &c., and which may possibly prove identical with those of the Cotentin.

Terebratula concentrica.
—— reticularis.
—— hastata.
—— pleurodon.
Spirifer Bouchardi.
—— calcaratus.
—— disjunctus.
—— protensus.
—— subconicus.
Orthis resupinata.
Strophomena senilis.
—— opercularis.
Leptæna Dutertrii.
Leptæna latissima.
Productus subaculeatus.
—— scabriculus.
Crania.
Serpula omphalodes.
Aulopora tubæformis.
Favosites polymorpha.
—— spongites.
Astræa ananas.
Cyathophyllum cæspitosum.
—— hexagonum.
—— turbinatum.
Calymene Latreillii.

Dolomitic Limestone.

A considerable thickness of red shales underlies the Fiennes and Ferques limestone and separates it from a band of compact dolomitic limestone, the harder portions of which may be seen projecting in rude weathered masses, above the usually level surface of the limestone district; this band is fossiliferous, but as the rock is not quarried, its contents are not easily ascertained. At the Boulogne Meeting Sir R. Murchison pointed out its mineral resemblance to the Dolomite of Gerolstein (Bull. de la Soc. Géol. de Fr. t. x. Dolomie Silurienne, p. 23). Its age or relative position is about the same.

The eastern breadth of this band on the surface is about 50 yards; it is underlaid by a thick series of argillaceous shales.

Blacourt Limestone.

Though this band may be identified at several places, it is only on the section S.W. from the farm of La Cédule, that the sequence of the lower portion of the series can be satisfactorily made out. The uppermost portion of this band consists of a rag-limestone, full of branches of *Favosites*, with thin carbonaceous seams and calcareous shales. The limestone strata beneath these are of considerable thickness; fossils are abundant in the partings of shale. This band has been quarried on the line of section from La Cédule; in a S.E. direction it crosses the road from Beaulieu to Les Communes, just where another branches off towards Caffiers: in the contrary direction it crosses the common land south of Landrethun, and is the limestone which is reached in the workings for iron-ore N. and E. of Blacourt.

The fossils of this band are—

Terebratula ambigua.
—— pleurodon.
—— reticularis.
—— concentrica.
Spirifer Bouchardi.
—— disjunctus.
Orthis resupinata.
Strophomena opercularis.
Leptæna Dutertrii.
—— fragraria.
Favosites polymorpha.
—— spongites.
Cyathophyllum turbinatum.

Blacourt Sandstone.

The above limestone is underlaid by shales, which separate it from a compact micaceous sandstone, very closely resembling that which is associated with the workable coal in the higher division of the series. On the section from La Cédule this band contains much diffused carbonaceous matter; at Blacourt it has impressions of Ferns, where I also found a portion of a Calamite; such indications as these may have suggested the trial for coal made some years since near Bainghen, and perhaps also that at Caffiers, near which this sandstone band passes.

Such a change as that here indicated by the intercalation of sands with a terrestrial vegetation, between two great groups of purely marine deposits, presents an instance of the recurrence of the like conditions over the same area.

The sandstone group is succeeded by shales, which are bright red above, passing into others nearly black: the superficial breadth of this division is upwards of 100 yards in the section from La Cédule. I was informed at Caffiers, that at the trial-shaft for coal they had ultimately met with limestone; if so, it must have been on this part of the series.

Limestone of La Cédule.

This is a compact sedimentary limestone, hard and splintery, with frequent interpolations of indurated shale. It rises near the farm of La Cédule, and, with the exception of some shales which underlie it, is the lowest portion of the Palæozoic group of the Boulonnais. There is an old quarry, which was worked in the thick middle beds of this zone, and both above and below the beds have more the character of black limestone shale; but if we include the whole in the limestone, it will have a breadth of 56 yards, with a dip to the S.W. of from 5° to 8°.

This band is seen for a short distance only; it crosses the high road from Landrethun towards Mimoyecques.

The following species were collected from the quarry near La Cédule:—

Terebratula ambigua.
—— reticularis.
—— pleurodon.
Spirifer Bouchardi.
Spirifer disjunctus.
Orthis resupinata.
Leptæna Dutertrii.

From the foregoing description it will be seen that a narrow belt only of Palæozoic strata is here exposed between a portion of the Oolite series on the S.W. and the Cretaceous series on the N.E., that it has a general strike from N.W. to S.E., and that though it presents two undulations, these are also in the same direction. The several sections taken give the following order of superposition (see Table):—

Division	Group	Succession of Beds.	Conditions Indicated.
Division 1.	A.	*a.* Pure massive limestone...... ↨	Deep open sea.
		b. Napoleon marble zone ...... ↨	Zone of Terebratula elongata.
		c. Thick-bedded limestone ... ↨	
			(Sequence broken.)
	B.	*d.* Micaceous sandstones: upper surface denuded.	Clean drift sand.
		e. Alternations of shales and marine sandstones.	Sublittoral oscillations: Productus.
		f. Shales and coal-seams ...... ↨ ↨	Ferns; Calamites. Alternations of terrestrial surfaces.
	C.	*g.* Black limestone: chert-seams .... ↨	Brachiopoda; Turbinoliæ.
		h. White friable limestone ... ↨	Productus giganteus zone.
		i. Calcareous sands .... ↨	Lithostrotion.
		j. Thin-bedded limestones and shales .... ↨	Productus, Spirifer.
			(Interrupted sequence of Hautbanc limestone.)
	D.	*k.* Lower limestone of Hautbanc, 170 feet thick. ...... ↨	Deep open sea.
Division 2.	E.	*l.* Shales........................ ↨	Facies of marine fauna changes.
		m. Clean micaceous sandstones ↨	Cucullæa, Cypricardia.
		n. Red shales and clays......... ↨	
	F.	*o.* Calcareous shales .... ↨	Zone of Spirifer Verneuilii.
		p. Coral limestone of Fiennes ...	Open sea coast-line distant.
		q. Shales.	
		r. Dolomitic lime and sand ... ↨	Drift beds.
		s. Shales .... ↨	
		t. Black compact limestone ... ↨	
		u. Shales........................ ↨	
		v. Micaceous sandstones, coarse ↨ ↨	Proximity of a terrestrial surface.
	G.	*w.* Red and black shales......... ↨	
		x. Black limestones .... ↨	
		y. Shales .... ↨	

§ 2. *The equivalents of the Palæozoic groups of the Boulonnais.*

The long series of oscillations here indicated, by which the same area was placed successively under such different conditions as to depth, had also this consequence—that at each change it became the ground of a fresh assemblage of animal forms. At intervals, which are wide apart in time, such as are represented by the limestones of the lower division (Ferques limestone down to that of La Cédule), and when somewhat like conditions were repeated, we meet with a recurrence of identical forms, which then prove the continuity of the same general Fauna; the differences which the intervals present, as mineral groups, are marked by corresponding changes in the animal series; in this, as in all such cases, the occupancy of an area, under any new conditions, must necessarily therefore have been by a process of immigration.

This consideration is of some importance with reference to all attempts at systematic classification: *like mineral groups, with identical faunas, are not necessarily synchronous; whereas many groups with nothing whatever in common, whether in respect of mineral composition or included fossil forms, must of necessity be of the same age*; yet the basis on which geological reasoning has usually proceeded for determining the equivalents of the component parts of great groups from one district to another, has been this—that like assemblages imply a perfect coincidence in time.

It is possible that the systematic arrangements of geologists may have been altogether premature; it is certain that they have been based on considerations which require much collateral support: the whole physical history of every portion of the area over which each perfect group extended, must be first made out, and even then we shall require to know much more than we now do, as to the habits of very many extinct forms, ere a "System" can be much more than a vague speculation; it is with extreme caution, therefore, that I propose the few following comparisons for the Palæozoic groups of the Boulonnais.

Geographically the Boulogne series is exposed mid-way between Devonshire and the Cotentin on the west, and a Belgic-Rhenish area on the east: as far back as 1839 I suggested a comparison between the South Devon and Eifelian calcareous groups. With reference to the Belgic area, it will be shown in the sequel, that the series of oscillations there was in strict correspondence along the whole line, extending from the east of the Ardennes to the Boulonnais; in other words, that a remarkable parallelism extends throughout the whole vertical thickness of the Anthraciferous series, up to the completion of the productive coal-measures. Such considerations cannot be extended to the West of England series, so that other terms of comparison are required. The great Anthraciferous period of Northern and Middle Europe, though it presents no abrupt geological break, yet readily admits of a twofold division, each of which has a facies of its own. Amongst the numerous forms which compose this fauna, there are very many of great range and endurance, and which may be altogether disregarded in comparisons of this sort: there are others apparently of very limited duration, such for instance, in the lower anthraciferous group, as *Posidonia, Strigocephalus, Calceola, Spirifer ostiolatus, Pleurodictyum*. The species of *Strigocephalus* are found

[Quart. Journ. Geol. Soc. vol. ix. Table to face p. 244.]

	Boulonn	*Middle Rhine (Sandberger).*	*Zones characterized by*
Upper Limestone.	1. . . .	. . . .	Terebratula elongata.
	2. . . .		
Coal-measures.	1. . . .		
	2. . . .		
Higher Mountain Limestone.	1. . . .	. . . .	Productus giganteus.
	2. . . .		
	3. . . .		
Lower Mountain Limestone.	Great		
	Shale	onomyen-schiefer . .	Posidonia Becheri; Goniatites crenistria.
	Dolor		
Yellow Sandstone Group.	Shale		1.
	Yello	ridinen-schiefer	2. Cypridina serratostriata, *Sandb.* Calymene granulata; Goniatites bifrons.
	Red s		
	Fossil		3. Cucullæa Haidingeri; C. trapezium.
Ferques and Fiennes Group.	Coral	aalstein	Sphæronites tessellatus.
	Shale	omite.	Cyrtoceras, pl. sp.
	Dolor	. . . .	Stringocephalus Burtini; Brontes flabellifer.
	Shale		
	Black	estone of Villmar. .	Calceola sandalina.
	Shale		
	Sands		
	Red s		
	Black		
	Lime	s of Wissenbach. . . .	Pleurodictyon problematicum.
		er sandstone series. .	Spirifer macropterus.

	Boulonnais.	*South Devon and Cornwall.*	*North Devon.*	*Wales, Somerset, and Midland and Northern Area.*	*Belgic area (Dumont).*	*Middle Rhine (Sandberger).*	*Zones characterized by*
Upper Limestone.	1.			Magnesian limestone series.			Terebratula elongata.
	2.						
Coal-measures.	1.	Some part of the C.-M. series unconformable in South Devon.	Coal measures.	Coal measures.	Coal measures.		
	2.						
Higher Mountain Limestone.	1.			Upper limestone.			Productus giganteus.
	2.			Gritstone series.	Calcaire de Visé.		
	3.						
					Argile de transition (*Léveillé*).		
Lower Mountain Limestone.	Great limestone			Great limestone.			
	Shales		Black limestones.	Lower Mountain limestone.	Lower Limestone of Tournay.	Posidonomyen-schiefer	Posidonia Becheri; Goniatites crenistria.
	Dolomitic limestone.						
Yellow Sandstone Group.	Shales	Red shales and sandstones of Torbay district.	Fremington; Pilton and Petherwin; Marwood sands. Morthoe groups.	Old Red Sandstone	Schistes et Psammites du Condros. Schistes fossilifères.	Cypridinen-schiefer	1.
	Yellow sandstone.						2. Cypridina serratostriata, *Sandb.* Calymene granulata; Goniatites bifrons.
	Red shales.						
	Fossiliferous shales						3. Cucullæa Haidingeri; C. trapezium.
Ferques and Fiennes Group.	Coral limestone	Upper Newton limestone	Ilfracombe group		Calcaire de Givet. Terrain Eifelien of Dumont.	Schaalstein	Sphæronites tessellatus.
	Shales.					Dolomite	Cyrtoceras, pl. sp.
	Dolomitic limestone.					…	Stringocephalus Burtini; Brontes flabellifer.
	Shales.						
	Black limestone.					Limestone of Villmar.	Calceola sandalina.
	Shales	Ogwell; Plymouth.					
	Sandstones	Shales with slate bands	Linton group		Sandstone and conglomerate of Burnot.		
	Red shales.						
	Black shales.						
	Limestone	Ashburton, Bickington and Chudleigh			Ahrien series of Dumont.	Shales of Wissenbach.	Pleurodictyon problematicum.
		Limestone					
		Sandstones			Rhenane series	Spirifer sandstone series.	Spirifer macropterus.

in a zone which extends from Plymouth to Newton, beneath the great coral limestone group; in North Devon they occur at the base of the thick calcareous series, which comes out on the sea-coast, in Combe Martin Bay; they have a like position in the limestone band of Givet. *Calceola* follows a like continuous and very narrow zone. We are safe therefore in placing the Ilfracombe group as the equivalent of the coral limestones of Newton; and in comparing both with the calcareous groups of Givet, of the Eifel, and of Villmar, in spite of the want of correspondence which they present in their mineral and organic compositions, simply because there are peculiar forms which occur but once in each series, and for a brief space only, when estimated with reference to the dimensions of these groups, and that it is not possible that these forms should range out of any beds, but such as were in immediate extension of those in which they were first introduced. Such zones become our only positive terms of comparison, and all that is required to render it complete is that the intermediate grouping should be in general harmony with the progressive change which the whole of the series exhibits. The grouping which such considerations suggest, is best exhibited in a tabular form; but there is one part of the upper Palæozoic series which has long been of interest to English geologists, and to which perhaps some have given an undue importance. The Old Red Sandstone of the British series is exhibited with such very characteristic features, over a large area, that we must necessarily assign it a representative position; but it must be borne in mind that this group is only an indication of certain conditions of accumulation, though of considerable continuity. Having seen the Old Red Sandstone in the counties of Hereford, Pembroke, Monmouth, and Somerset, I may state that this portion, which is its typical mass, belongs to the littoral, sublittoral, and drift-sand zones, and that as such it can only be a subordinate group in a perfect series of marine sedimentary deposits; the distance, however, is not so great but that we might look for it in some approximately recognizable form in the south of the Exmoor range, unless that district had been raised out of the area of the sedimentary beds of that period, a supposition which cannot be entertained. It must be remembered, that for the area above referred to, the Old Red Sandstone is a continuous group, which must always be the strongest proof of identity of geological age. In Somerset as elsewhere the Old Red Sandstone passes into the Lower Mountain Limestone, by a series of beds which indicate a progressive increase of depth merely, but no cessation. I am therefore unable to adopt the classification proposed by Mr. Sharpe in a recent communication*, the result of our Belgian excursion, as it would make the Old Red Sandstone older than the calcareous group of South Devon. The changes which such beds as those of the Old Red Sandstone may be expected to present elsewhere, depend on the determination of the physical changes which affected Western Europe anterior to and during the Anthraciferous period; these changes are indicated in the second part of this communication, and in accordance with these, I have neither looked for typical Old Red Sandstone, nor Mountain Limestone, but simply for representative conditions.

* Quarterly Journal, vol. ix. p. 26.

Note by D. Sharpe, Esq., F.G.S.

My dear Sir,—In compliance with your request, I have drawn up a list of the palæozoic fossils which we collected in the Boulonnais (see Tabular List), adding such other species (with an asterisk attached) as are recorded in the accompanying list, p. 250. A review of the organic remains in these beds will lead to some interesting results.

The two great bands of carboniferous limestone of the Carrières Napoléon and of the Haut Banc must be classed from their fossils in the upper and middle divisions of the Carboniferous Limestone formation, corresponding with the limestones of Bristol and Derbyshire, with those of Yorkshire (with the exception of the lowest beds), and with that of Visé in Belgium. The presence of coal between these two beds of marine limestone is analogous to what Mr. Phillips long ago described in Yorkshire. Coal-beds of a similar age are also found in Coalbrook-dale and in the Lothians, but the upper limestones of those localities are mostly of freshwater origin.

The shales below the Haut Banc limestone have not yet supplied any organic remains; but the beds of yellow sandstone on which they rest are interesting to us, as they contain the species of *Cucullæa* which abound in the sandstone of Marwood, in North Devon, and thus fix the place of that bed in the geological series, which was previously somewhat obscure.

All the beds which crop out on the surface from below the yellow sandstone belong to one formation, and contain nearly the same species of organic remains; the Ferques limestone is the most important of these, and is the most exposed to observation; it has in consequence yielded the richest harvest to the palæontologist*. These beds have hitherto been classed in the Devonian series, but if that view be correct, there can be in this district no representative of the Tournay limestone or lower division of the Carboniferous Limestone series, and the middle division of that series must here rest conformably on the top of the Devonian formation.

The Ferques limestones have been called Devonian, on the principle that the Devonian system includes all the beds between the Carboniferous Limestone and the Silurian rocks; but the base-line of the Carboniferous Limestone has been drawn upon different principles in different districts, so that beds which ought to be classed together as of one age are called *Carboniferous* in Ireland and Northumberland, and *Devonian* in Devonshire and the Boulonnais. On the other hand, the Devonian system has been made to include beds as well distinguished by organic remains as the upper Silurian formation is from the lower†. It is high time for us to follow the good example

* M. de Verneuil; Bull. Soc. Géol. Fr. vol. ix. p. 388, 1838.
Sir R. I. Murchison; vol. xi. of the same, p. 240, 1840.
Mr. Lonsdale; Trans. Soc. Geol. 2 ser. vol. v. p. 736, 1840.
Visct. d'Archiac and M. de Verneuil, *ib.* vol. vi. p. 380, 1841.
MM. Milne-Edwards & Haime, Archives du Muséum, vol. v.

† At the late meeting of the British Association at Belfast, the inconsistency of the line of separation between the Devonian and Carboniferous formations of the north and south of Ireland was pointed out by Mr. Jukes. See Literary Gazette of 25th Sept. 1852.

set us by M. Dumont, to which I lately called the attention of the Society, and to endeavour to divide into natural groups this vast series of strata hitherto thrown together almost indiscriminately.

The nearest resemblance in this country to the Ferques limestones is found in the beds of South Petherwin and Tintagel in Cornwall, Barnstable, Pilton, and Croyde in North Devon (especially the former), in which we find the same abundance of *Spirifer disjunctus* (*S. Verneuilii*) and *Sp. calcaratus* (*Sp. Archiaci*) in all their numerous varieties, together with many other species in common. These therefore may be taken together as a well-marked group of beds, which for the sake of convenience may be called the Petherwin Group, that name having already been adopted by Professor Sedgwick. The Cucullæa sandstone must be regarded as a subordinate member of this group, since it occurs above the limestone of Ferques and below the Barnstable and Pilton beds. The English deposits classed with the Ferques limestones differ from the latter in wanting the Devonian and Silurian corals which form so marked a feature at Ferques; but coral-reefs are everywhere so local that no argument can be drawn from their absence.

On comparing the organic remains of the Petherwin group with the next group below it (which is the Eifelian series of M. Dumont, including the limestones of the Eifel and of S. Devon), we find most of the corals and many of the shells of Ferques occurring also in the Eifelian group, but there are also many of the most abundant species at Ferques which are not found in the Eifelian bed. And if we look over the Eifelian species enumerated in the list of MM. d'Archiac and de Verneuil, we shall find that not one-seventh are continued into the Petherwin group of beds, and that the most characteristic of the Eifel species are not found in the upper deposit, viz. *Spirifer aperturatus*, *S. ostiolatus*, and *S. speciosus*, *Terebratula ferita*, *Calceola*, *Strigocephalus*, &c.

Many of the shells, but few of the corals, of Ferques are found in the Carboniferous Limestone*, so that from the organic remains alone it might be doubtful whether we should refer the Petherwin series to the Carboniferous or the Devonian system, though the balance would probably incline in favour of the former classification.

But the conformable stratification of the Ferques beds with the overlying Carboniferous series of the Boulonnais, and the similar conformity of the Petherwin and Pilton groups to the Culm-measures of Devonshire, connect the Petherwin group with the Carboniferous series, while the complete break between the Petherwin and Pilton groups and the true Devonian rocks below separates them from the latter system.

Therefore, while admitting that the change from the Devonian to the Carboniferous series has been very gradual, I think that the balance of evidence places the Petherwin group as a lower member of the Carboniferous series.

* I do not include Prof. M'Coy's Irish localities in this calculation, as they probably refer to beds of the Petherwin age, and not to the typical Carboniferous Limestone.

In Devonshire we find the top of the Petherwin series well-defined by the shales containing *Posidonia Becheri* in great abundance. Shales crowded with the same *Posidonia* guide us in separating the Petherwin series from the Carboniferous Limestone in Northumberland. The limestone of Hook Point, Waterford, undoubtedly belongs to the same group, as also many beds in other parts of Ireland classed by Mr. Griffiths and Prof. M'Coy in the Carboniferous Limestone; and also the limestone of Senzelles in the Province of Namur, Belgium.

When we compare together the organic remains of the Silurian, Devonian, and Carboniferous periods, we find that many species of corals lived on from the Silurian through the Devonian epochs; but although the Carboniferous Limestones are often full of corals, these are of species different from the Devonian corals: thus there was a complete change of the species of corals between the end of the Petherwin and the beginning of the Carboniferous period*. But the greatest change in the species of Mollusca was between the Silurian and the Devonian periods, and many species lived on from the Devonian to the Carboniferous periods. Corals appear so sensitive to changes of climate, that the above facts make it probable that there was no material change of climate during the long period of time in which the Silurian and Devonian rocks were deposited, and the complete extinction of the then existing corals at the close of the Devonian and Petherwin period may have been caused by a change of climate.

A change of climate sufficient to destroy the Devonian corals might have left uninjured the Mollusca inhabiting deeper waters; but it is difficult to find a cause for the extinction of so many Silurian Mollusca in seas which continued to support the same species of Corals.

But let us return to the Boulonnais. I stated above that all the lower beds which come to the surface contain nearly the same fossils as the Ferques limestone; but the shaft sunk at Caffiers in a fruitless search for coal passed into still lower beds of dark grey schists containing a fossil which at the Boulogne meeting was pronounced to be a Graptolite†, and which in the Museum of that town is labelled *Graptolithus sagittarius*.

As the *Graptolithus sagittarius* has hitherto been only found in the Lower Silurian series, its presence at Caffiers would show that the Ferques beds rested immediately on Lower Silurian rocks; or if the specific name is abandoned, as Graptolites have only been found in the Silurian system, the Ferques beds must at least rest on Silurian strata, without the intervention of any portion of that enormous series of Eifelian and Rhenane rocks which both on the Belgian side of the Ardennes and in Devonshire separate the Petherwin series from the Silurian formations: therefore the correct identification of the Caffiers fossil becomes of great geological interest.

* For these facts we are mainly indebted to the labours of Mr. Lonsdale.

† Bull. Soc. Géol. Fr. vol. x. pp. 398, 401, & 416, and vol. xi. p. 250.

The mass of schist from Caffiers now in the Boulogne Museum contains many specimens of the fossil in question, and undoubtedly some of them strongly resemble Graptolites ; but the best-preserved specimens exhibit characters which prove them to be plants ; they consist of slender stems bearing two rows of closely set alternating leaflets, the bases of which overlap ; the leaflets are sessile, lanceolato-ovate, with a strong midrib ; they resemble in form the leaves of *Knorria,* but are set in two rows on opposite sides of the stem instead of encircling them as in that genus.

It thus appears that there remains no evidence whatever for classing any of the deposits of the Boulonnais in the Silurian system.

[D. S.]

[*See List of Fossils, in the following pages.*]

	Silurian.	*Eifelian.*		*Carboniferous.*	
Serpula omphalodes, Goldf. 67. f. 3	....	Eifel........	Ferques ...	Hook Point.	
*Chætetes Goldfussi, Edwards and Haime, Arch. Mus. t. 5. f. 269.	....	....	Ferques.		
*Aulopora conglomerata, Goldf. 29. f. 4; Lonsd. Sil. Syst. 15. f. 9.	Wenlock L........	Eifel, S. Devon	Ferques ...	....	A. & V.
*—— repens, Goldf. 29. f. 1	....	Eifel, &c.	Ferques.		
—— tubæformis, Goldf. 29. f. 2; *A. cucullina*, Michelin.	Wenlock L........	Eifel........	Ferques.		
*Favosites alveolaris, De Blainv. Lonsd. Sil. Syst. 15 *bis*, f. 1 & 2.	Aymestry, Wenlock	Eifel........	Ferques ...	....	A. & V.
—— spongites, Lonsd. Sil. Syst. 15 *bis*, f. 8; Goldf. 28. f. 1 & 2.	Wenlock L........	Eifel, S. Devon	Ferques ...	Ireland.	
—— polymorpha, Goldf. 2. fig. 2–4; Lonsd. Sil. Syst. 15 *bis*, f. 2; *P. dubia*, Edwards and Haime, Arch. Mus. t. 5. p. 243.	Aymestry........	Eifel, S. Devon	Ferques ...	Ireland.	
Astræa ananas, Lam. Lonsd. Sil. Syst. 16. f. 6...	Wenlock	Eifel........	Ferques.		
*Zaphrentis Cyathophylloides, Edwards and Haime, Arch. Mus. t. 5. f. 8.	....	....	Ferques.		
*Strombodes vermicularis, Goldf. 17. f. 4; Lonsd. G. T. 5. t. 58. f. 7.	Gothland........	Eifel, S. Devon	Ferques ...	Ireland.	A. & V.
*Metriophyllum Bouchardi, Edwards and Haime, Arch. Mus. 5. t. 7. f. 1.	....	....	Ferques.		
Cyathophyllum cæspitosum, Goldf. 19. f. 2; Lonsd. Sil. Syst. 16. f. 10; *C. Marmini*, Edwards and Haime, Arch. Mus. 5. t. 9. f. 2.	Wenlock L........	Eifel, S. Devon	Ferques.		
—— turbinatum, Goldf. 16. f. 8; Lonsd. Sil. Syst. 16. f. 11.	Wenlock L........	Eifel, S. Devon	Ferques ...	Ireland.	
*—— Decheni, Edwards and Haime, Arch. Mus. 5. p. 365.	....	Eifel........	Ferques.		

* I have not myself seen the species marked with an asterisk; the authorities for their being found at Ferques are given in the last column, A. & V. referring to the list of Devonian species, by MM. d'Archiac and de Verneuil, in the Trans. Geol. Soc. 2 ser. vol. vi.

	Silurian.	Eifelian.		Carboniferous.	
*Cyathophyllum Michelini, Edwards and Haime, Arch. Mus. 5. p. 366.		Eifel	Ferques.		
*—— Bouchardi, Edwards and Haime, Arch. Mus. 5. t. 10. f. 2.			Ferques.		
—— hexagonum, Goldf. 20. f. 1; *C. Boloniense*, Edwards and Haime, Arch. Mus. 5. t. 9. f. 1.		Eifel	Ferques		Murch. Bull.
*—— radicans, Goldf. 16. f. 2		Eifel	Ferques		De Vern. Bull.
*Fenestella antiqua, Goldf. 36. f. 3; Lonsd. Geol. Trans. 5. t. 15. f. 16.		S. Devon	Ferques, Croyde, Petherwin.	Ireland.	De Vern. Bull.
*Campophyllum flexuosum, Goldf. sp. 17. f. 3; Edwards and Haime, t. 8. f. 4.		Eifel, S. Devon	Ferques.		
*Retepora prisca, Goldf. 36. f. 16; Phill. P. F. 37.		S. Devon	Ferques	Wexford.	De Vern. Bull.
*Trachypora Davidsoni, Edwards and Haime, Arch. Mus. 5. t. 17. f. 7.			Ferques.		
*Pachyphyllum Bouchardi, Edwards and Haime, Arch. Mus. 5. t. 7. f. 7.			Ferques.		
Thecostegites Bouchardi, Edwards and Haime, Arch. Mus. 5. t. 14. f. 1.			Ferques.		
*Dendropora explicita, Edwards and Haime, Arch. Mus. 5. p. 304.			Ferques.		
Calymene Latreillii, Stein. Phill. P. F. 249		S. Devon	Ferques, Pilton.		
*Murchisonia tricincta, var. *b*, Phill. P. F. 60		Newton, Elbersreuth	Ferques		A. & V.
*Euomphalus radiatus, Goldf. Phill. P. F. 171†		Eifel, Newton	Ferques		Lonsdale.
Euomphalus, n. s.			Ferques.		
*Terebra Hennahii, Sow. G. T. 2 ser. 5. t. 57. f. 22		Plymouth	Ferques	Carluke.	Lonsdale.
Cucullæa Hardingii, Sow. G. T. 2 ser. 5. t. 53. f. 26, 27; Phill. P. F. 67.			Ferques, Marwood.		

	Silurian.	*Eifelian.*		*Carboniferous.*
Cucullæa Trapezium, Sow. G. T. 2 ser. 5. t. 53. f. 24; Phill. P. F. 70; *C. angusta*, Sow. l. c. f. 25; Phill. P. F. 68; *C. unilateralis*, Sow. l. c. f. 23; Phill. P. F. 69.	....	....	Ferques, Marwood.	
—— ? amygdalina, Phill. P. F. 66	....	....	Ferques, Marwood.	
Terebratula concentrica, Von Buch	....	Eifel, Newton	Ferques ...	Hook Pt. Common in Ireland (M'Coy).
—— reticularis, Linn.	Up. Sil. *passim* ...	Eifel, S. Devon, &c.	Ferques ...	Ireland.
—— aspera, Schl.	Gothland	Eifel, S. Devon, &c.	Ferques ...	Ireland... Bouchard Mus.
—— hastata, Sow., with T. virgo, Phill.	....	S. Devon	Ferques ...	*passim.*
—— pleurodon, Phill.	....	S. Devon	Ferques, Pilton, S. Petherwin.	*passim.*
—— ambigua, Sow.	....	....	Ferques ...	*passim.*
Spirifer subconicus, Phill. P. F. 126; not of Martin; Sow. G. T. 5. t. 57. f. 10?	....	Eifel, S. Devon	Ferques.	
—— calcaratus, Sow. G. T. 5. t. 53. f. 7; Phill. P. F. 128 β; *S. Archiaci*, Murch. Bull. Soc. Géol. Fr. 11. t. 2. f. 4.	....	....	Ferques, Petherwin, Barnstable.	Soignies. Ireland.
—— disjunctus, Sow. G. T. 5. t. 53. f. 8, t. 54. f. 12, 13, t. 55. f. 2; Phill. P. F. 128 *a, f, g, h*, & 129; *S. giganteus*, Sow. l. c. t. 55. f. 1–4; Phill. Pal. Foss. 130; *S. inornatus*, Sow. l. c. t. 53. f. 9; *S. extensus*, Sow. l. c. t. 54. f. 11; *S. Lonsdalii*, Murch. l. c. t. 2. f. 2; *S. Verneuilii*, Murch. l. c. t. 2. f. 3.	....	Hope	Ferques, Petherwin, Barnstable.	Ireland.
—— Bouchardi, Murch. l. c. t. 2. f. 5; *Cyrtia laminosa*, M'Coy, Carb. Foss. t. 21. f. 5.	....	....	Ferques ...	Ireland.

	Silurian.	*Eifelian.*		*Carboniferous.*	
*Spirifer heteroclitus, De Blainville, Phill. P. F. 125.		Eifel, Newton	Ferques ...	Tournay.	A. & V.
—— protensus, Phill. Pal. Foss. 118			Ferques, Petherwin.	Ireland.	
Orthis resupinata, Martin; *O. striatula*, Schloth.; *O. connivens*, Phill. Yorksh. t. 11. f. 2.		Eifel, S. Devon	Ferques, Petherwin.	*passim.*	
Strophomena senilis, Phill. sp. Yorksh. 2. t. 9. f. 5; *O. umbraculum var.*, Koninck, t. 13. f. 7, not t. 13. f. 4.			Ferques ...	Bolland, Tournay.	
—— opercularis, De Vern. sp. Russie, 2. t. 13. f. 2; *O. orbicularis*, Murch. Bull. Soc. G. Fr. 11. t. 2. f. 8, not of Sow. Sil. Syst.; probably *O. interlineata*, Sow. G. T. 5. t. 54. f. 14; Phill. Pal. Foss. 106.		Eifel	Ferques, Petherwin? Croyde?		
Leptæna Dutertrii, Murch. Bull. Soc. G. Fr. 11. t. 2. f. 6; *O. interstrialis*, Phill. P. F. 103.		S. Devon	Ferques.		
—— Fragaria, Sow. Trans. Geol. Soc. 5. t. 54. f. 3, t. 56. f. 5, 6; *Orthis productoides*, Murch. Bull. Soc. G. Fr. 11. t. 2. f. 7.		S. Devon	Ferques, Petherwin.		
—— latissima, Bouchard, MSS.			Ferques.		
Productus subaculeatus, Murch. Bull. Soc. G. Fr. 11. t. 2. f. 9.		Eifel	Ferques ...	Ireland.	
—— scabriculus, Sow. M. C. t. 69. f. 1			Ferques, Pilton.	*passim.*	
Crania			Ferques.		

[D. S.]

DONATIONS

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I. TRANSACTIONS AND JOURNALS.

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Asiatic Society of Bengal, Journal. No. 229.

Assurance Magazine. No. 10. *From the Institute of Actuaries.*

Athenæum Journal, for January, February.

Berlin Academy. Abhandlungen der Königlichen Akademie der Wissenschaften, 1851.

———. Monatsbericht, July—October 1852.

Bologna Academy. Nuovi Annali delle Scienze naturali. Serie 3. tomo iv. Sett. e Dec. 1851; tomo v. Mag. e Giug. 1852; and tomo vi. Lug. e Ago. 1852.

Bombay Geographical Society, Transactions. September 1850 to June 1852.

Breslau Academy. Neun und zwanzigster Jahresbericht der Schlesischen Gesellschaft für vaterländische Kultur.

Breslau Academy. Verhandlungen der kaiserlichen Leopoldinisch-Carolinischen Akademie der Naturforscher. Vol. ii. Supplement.

Canadian Journal for October, December 1852, January 1853.

Chemical Society, Quarterly Journal. No. 20.

Civil Service Gazette. No. 1.

Helvetic Society. Denkschriften der allgemeinen Schweizerischen Gesellschaft für die gesammten Naturwissenschaften. B. 1. Abth. 2.

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———. Statuten und Reglemente, 1847. *From Sir R. I. Murchison, F.G.S.*

Hesse. Verhandlungen des naturhistorischen Vereins für das Grossherzogthum Hessen und Umgebung. H. 2. *From Sir R. I. Murchison, F.G.S.*

Horticultural Society, Journal. Vol. viii. part 1.

Institut des Provinces et des Congrès Scientifiques, Annuaire, 1853. *From T. Davidson, Esq., F.G.S.*

Journal of the Indian Archipelago. Vol. vi. nos. 7, 8, 9. *From J. R. Logan, Esq., F.G.S.*

Madrid, Memorias de la Real Academia de Ciencias de. Tomo i. parte 2.

———. Resumen de las Actas, &c., 1850 à 1851.

Milan. Memorie dell' I. R. Istituto Lombardo di Scienze, Lettere ed Arti. Vol. iii.

———. Giornale. N. S. tomo ii. fasc. 7–12, tomo iii. fasc. 13–18.

Paris, Archives du Muséum d'Histoire Naturelle. Tome vi. Livr. 3 & 4.

———, l'Académie des Sciences de. Comptes Rendus, Deux. Sem. tome xxxv. nos. 20–36, et Prem. Sem. tome xxxvi. nos. 1–10.

Philosophical Magazine, for January, February, March. *From R. Taylor, Esq., F.G.S.*

Photographic Society, Journal. No. 1.

Royal Agricultural Society of England. Vol. xiii. part 2.

Royal Irish Academy, Transactions. Vol. xxii. parts 3, 4.

———, Proceedings. Vol. v. part 2.

Royal Society, Proceedings. Vol. vi. nos. 91 & 94.

Society of Arts, Journal. Nos. 7–17.

Van Diemen's Land, Papers and Proceedings of the Royal Society of. Vol. ii. part 1.

II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names of Donors in Italics.

Athenæum Club, Rules, Regulations, and List of Members. 1852.

Bigsby, Dr. J. J. The Shoe and Canoe, or Pictures of Travel in the Canadas. 2 vols.

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Campbell, D. F. Translation of M. Chevalier's Remarks on the Production of the precious Metals.

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Ordnance Survey. Astronomical Observations made with Airy's Zenith Sector, from 1842–50. *From the Hon. Board of Ordnance.*

Owen, D. D. Report of a Geological Survey of Wisconsin, Iowa, and Minnesota; with Illustrations.

Phillips, John. A Treatise on Geology. 2 vols.

———. The Rivers, Mountains, and Sea-coast of Yorkshire.

Pictet, F. G. Traité de Paléontologie, ou Histoire Naturelle des Animaux fossiles. 2 edit. tom. prem. & planch. 1–28.

Ponzi, Prof. G. Osservazioni Geologiche fatte lungo la Valle Latina. *From Sir R. I. Murchison, F.G.S.*

Prestwich, J. On the Structure of the neighbourhood of Gamrie, &c. *From Sir R. I. Murchison, F.G.S.*

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Regulations for the Management of the Gold-fields of New South Wales. *From the Colonial Office.*

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Reports of Geological Surveys in New South Wales. *From the Colonial Office.*

Reports by the Jurors on the subjects in the Exhibition of the Works of Industry of All Nations, 1851. *The Commissioners.*

Rœmer, Dr. F. Die Kreidebildungen von Texas und ihre organischen Einschlüsse.

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Zeisznera, Dr. L. O formacyi Jura nad Arzeg ami Wisly. *From Sir R. I. Murchison, F.G.S.*

———. Opis geologiczny Szczawnicy i Szlachtowéj. *From Sir R. I. Murchison, F.G.S.*

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

May 4, 1853.

Philip W. Wall, Esq., C.E., was elected a Fellow.

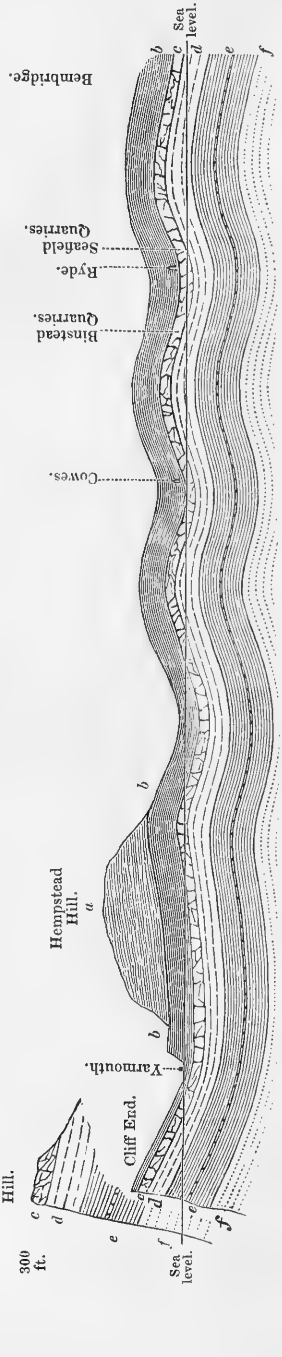
The following communications were read :—

1. *On the* Fluvio-marine Tertiaries *of the* Isle of Wight. By Professor Edward Forbes, F.R.S., Pres. G.S., &c.

The purpose of the following communication is briefly to state the results of a recent investigation of the fluvio-marine tertiaries of the Isle of Wight, undertaken in the course of the labours of the Geological Survey. I was directed by Sir Henry De la Beche to examine the distribution of organic remains in the various strata of that island, and to devote the months of October, November, and December 1852, and January 1853, to the work. I found so much in the fluvio-marine Eocene strata that was not only palæontologically but also geologically new, that I was obliged to devote almost the whole of the time mentioned to their examination; nor was the constant and daily labour, with able assistance, during four months on these interesting beds more than sufficient for their exploration. During most of the time I was accompanied by my colleague Mr. Bristow, and assisted by skilful collectors, especially Mr. Gibbs.

As numerous memoirs by eminent geologists, British and foreign,

Fig. 1.—*Diagram-section of the Eocene Tertiaries of the Isle of Wight.*



a. Hempstead series, 170 feet thick.
b. Bembridge marls, 80 feet thick.
c. Bembridge limestone, 30 feet thick.
d. St. Helens beds, 100 feet thick.
e. Headon series, 180 feet thick.
f. Headon sands, 100-200 feet thick.

have been published treating of the strata under consideration, it might seem that little new could be made out respecting them except concerning minute details. I certainly went to my work expecting to find an easy and speedy task, and it may seem almost like presumption when I state as the general result, that not only was the duty to be done far more laborious and novel than could have been looked for, but that the geology of the district under consideration had been, in great part, seriously misunderstood by all who had explored it.

The interpretation usually hitherto accepted of the structure of that part of the Isle of Wight composed of fluvio-marine Eocenes, constituting the greater part of the island north of the great chalk ridge, is that the series of beds exposed in the section of Headon Hill, and constituting the Headon Hill sands, Lower freshwater, Upper marine, and Upper freshwater of Webster, includes the whole thickness of the fluvio-marine Eocenes, and that the greater part of the superficial area is occupied by the Lower freshwater division. This view, which originated with Professor Webster, was supported and maintained in detail by Professor Sedgwick, and has been adopted by most subsequent writers.

Two geologists only have surmised the existence of higher beds than those of Headon, viz. Mr. Prestwich and M. Hébert. The former, in 1846, described briefly the strata composing a part of Hempstead Hill to the east of Yarmouth, and suggested that those beds pre-

viously regarded as Lower freshwater, capped by the Upper marine, were really probably higher than any beds hitherto noticed. The latter, in 1852, maintained that the section between Tolland Bay and Sconce Point, near Yarmouth, included a series of beds higher in geological position than those composing Headon Hill. That Mr. Prestwich was right in his anticipation I shall have the pleasure of proving beyond question, but cannot assent to the conclusion of M. Hébert, whilst admitting that his opinion on all points concerning the Eocene tertiaries demands the highest respect.

All geologists, without exception, who have compared the section at Whitecliff Bay, at the eastern end of the island, with that of Headon at the western, have regarded the fluvio-marine series in the former place as the equivalents of that in the latter (see fig. 3). Nor do any seem to have suspected that the fluvio-marine beds at Whitecliff were in considerable part superior to those of Headon (see fig. 2).

Figs. 2 & 3.—*Diagram-Sections of Whitecliff Bay.*

Fig. 2.—*The hitherto received version.*

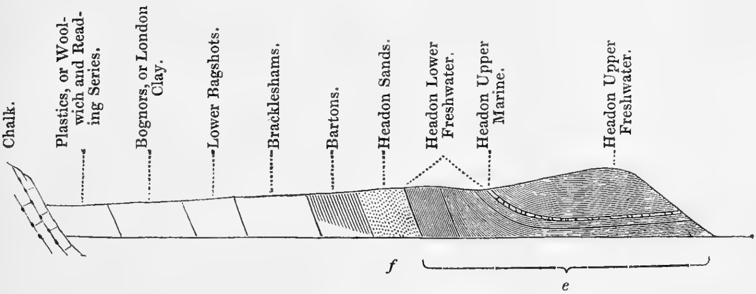
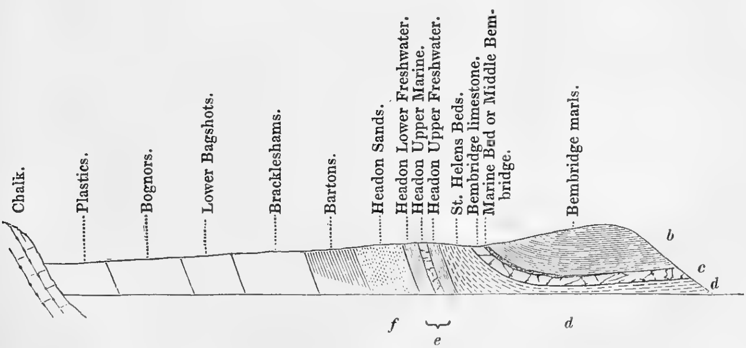


Fig. 3.—*The new reading.*



b. Bembridge marls, 80 feet thick.
c. Bembridge limestone, 30 feet thick.
d. St. Helens beds, 100 feet thick.
e. Headon series, 180 feet thick.
f. Headon sands, 100-200 feet thick.

The famous mammaliferous limestones of Binstead and Seafield have always been considered equivalents of some of the Headon beds, usually as equal to the Lower freshwater limestones.

Respecting the foreign equivalents of the Headon Hill series (above the Headon sands), there have been conflicting opinions.

The oldest view, originally suggested by Webster, was, that they represent the whole series of tertiaries above the Calcaire grossier in the Paris basin.

M. d'Archiac (1849) regarded them as representing his fifth group, that of the Calcaire silicieux only, and as possibly represented by the Sables de Diest in Belgium.

M. Dumont (1851) identified them with his Tongrien system of Belgium, the Limburg beds of Sir Charles Lyell.

M. Hébert (1852) maintained that the Venus-bed of Colwell Bay was higher in the series than the strata of Headon Hill, and was the true representative of the Grès de Fontainebleau and Limburg beds. The Hordwell freshwaters he compared with those of Montmartre, and the Barton marine beds with the Grès de Beauchamp.

A very different view of the relative position of the Headon beds was taken by Mr. Prestwich, who, in 1847, argued that they belonged to a much lower place in the series, and were the equivalents of the upper portion of the Calcaire grossier.

A statement of the conclusions to which I have come from my own observations will serve to show the points of difference between them and those arrived at by previous investigators.

The section at Headon Hill includes only a portion of the fluvio-marine strata of the Isle of Wight, and the greater part of the surface of the island north of the chalk ridge is occupied by beds higher in geological position than any seen in Headon.

The section at Whitecliff Bay includes not only all the fluvio-marine series at Headon Hill, but also a thickness of nearly 100 feet of strata higher than any seen in that locality.

The section at Colwell Bay is composed entirely of beds present in Headon Hill.

Hempstead Hill, east of Yarmouth, contains between one and two hundred feet of beds higher than those concluding the series at Whitecliff Bay. Equivalents of these beds seem to be present at Parkhurst, but nowhere else in the island.

The Limestones of Binstead, Seafield, Colborne, and Sconce belong to the same bed with the Limestone of Bembridge Ledge, which is not the equivalent of any of the conspicuous limestones of Headon, but is there represented by a calcareous marl, mostly concealed by grass and lying immediately under the newer tertiary gravel that crowns the hill.

The greater part of the surface occupied by fluvio-marine beds in the Isle of Wight is formed of the marls that lie above the limestone at Bembridge and Whitecliff (see fig. 1).

The contour of the surface of the north end of the island depends on the gentle rolling, *in two directions*, of the tertiary strata, the one series of rolls parallel with the chalk ridge and the other at right angles to it. The former rolls are connected with the movement that elevated vertically the chalk and neighbouring strata. The latter appear also to affect the chalk, since each north and south valley formed by the synclinal curve of a roll corresponds to the division between two chalk downs, and each down to an anticlinal. All the valleys of the north of the island depend for their form upon synclinals, and all the ridges on anticlinals. All the Eocenes (under which term I include, for reasons hereafter to be stated, *all* the fluvio-marine beds) are affected by these movements. The gravels which rest upon them, whether the more ancient or higher level gravels, or the newer, such as those that occupy coombs or that form thick beds (40 feet thick) at Foreland, are unaffected by these movements.

Palæontologically, the Headon beds (exclusive of the marls capping the hill before alluded to) form a distinct group from the Bembridge limestone and its associated marls; and these in their turn constitute a distinct series, so far as fossils are concerned, from the Hempstead beds.

Arguing from both order of superposition and fossil contents, I am induced to maintain that the series of beds hold the following relations to the Paris and Belgian groups :—

1st. The Headon Hill sands and the freshwater beds lying between them and the Upper marine and Upper freshwater beds in Headon Hill, are, as maintained by Mr. Prestwich, the equivalents of the upper part of the Calcaire grossier.

2nd. Certain strata, termed by me the St. Helens beds, intermediate between the Headon series proper and the Bembridge limestones, probably in connection with the upper and middle Headons, represent the Grès moyens.

3rd. The Bembridge limestones and marls are the equivalents of M. d'Archiac's fifth group—the gypseous series, or Calcaire lacustre moyen, with its associated beds, and of the Lower Tongrien of Belgium.

4th. The Hempstead series represents the fourth group of M. d'Archiac, and possibly part of his third group, the former including the Grès et sables supérieurs (Grès de Fontainebleau), and the latter the Calcaire lacustre supérieur. It represents also the middle and possibly the upper Limburg beds of Belgium.

If this arrangement be accepted, the prevalent classification of a considerable portion of the Tertiaries of Europe and the Mediterranean basin will be materially affected. Continental geologists are, with a few exceptions, inclined to refer the fourth and fifth groups of M. d'Archiac's arrangement to the Miocene formation. By Sir Charles Lyell, however, they have been regarded as Upper Eocene. It would seem that to this section are referable many of the older tertiaries of France, including important beds of the Bordeaux basin, many of the beds called Molasse, important strata in the

Vienna and Mayence basins, and others in Portugal, Spain, Malta, Corsica, Greece, &c. Of these many have been hitherto always described as Miocene.

In the Isle of Wight, the series of beds, from the uppermost of the Hempstead series to the Barton clays (not to speak of the remainder of the Eocene series), is in perfect conformity throughout, and, whilst the distinctive palæontological features of the several sections are unmistakeably defined, each group is linked with its neighbours by fossils common to it and them, in a manner clearly indicative of perfect geological sequence. The line drawn by foreign geologists between Miocene and Eocene is, if I am right in my comparisons, that which I have drawn between the Hempstead and Bembridge groups. But in the Isle of Wight this line is more convenient on account of mineral and topographical features, than because it marks any interruption of continuity. In truth these two groups pass into each other. Bearing in mind, then, the discordance between the Touraine Faluns (the typical Miocene of Sir Charles Lyell) and the so-called "Lower Miocene" in France, as well as the great distinctness of their fauna, I think the facts which I am bringing forward in this notice should go far towards the assignment of the Grès de Fontainebleau and its equivalents to the Eocene or Older Tertiary epoch.

Although, in a full memoir upon this subject, which will appear hereafter in the "Records of the Geological Survey," I shall describe in minute detail the phænomena of the Headon beds and underlying sands exhibited at Headon and in Colwell and Whitecliff bays, it is scarcely necessary to do so at present, since so many and able accounts of them have appeared from time to time, and several have been published by the Society. The sections of the fluvio-marine beds of Headon Hill by Mr. Prestwich, that of Colwell Bay by Dr. Wright, and those of Whitecliff Bay by Mr. Prestwich, Capt. Ibbetson, and myself, all enumerate the succession of beds in detail. After the publication of the two first-mentioned, it seems difficult to understand how M. Hébert has come to the conclusion that the Colwell beds are distinct from and higher than the strata in Headon Hill. In conjunction with Mr. Bristow I have carefully and minutely made fresh separate sections of each of those localities as they appeared last year, with notes of the fossils of every bed, carefully examined on the spot. The apparent differences depend upon the more marine character of the "Upper Marine" or Middle Headons at Colwell, than at Headon, a difference similarly marked at Hordwell, and still more at Whitecliff.

The freshwater limestones, which constitute so conspicuous and important a part of the section at Headon Hill, pass into soft beds northwards, and very soon appear to have entirely vanished, or rather to have been represented by clays and marls westward, so that in the sections at Whitecliff Bay they are no longer recognizable. Influenced by their dominant character at Headon, however, all geologists who have described the Whitecliff section, or any other tertiary portions of the Isle of Wight, have identified with them, or rather

with those of the lower freshwater division of the Headon series, the equally conspicuous and far more important and constant limestone of Bembridge. The oyster-bed that lies immediately above the latter has been constantly mistaken for the "Upper Marine" of Headon; and in order to account for the greater thickness of the fluvio-marine series at Whitecliff, it has been supposed that the Headon series, like several of the Eocene beds of older date at the same place, has thickened out westward. A close inspection of the Whitecliff section will show that the whole of the Headon series proper is preserved of nearly equal thickness at Whitecliff and at Headon; in the former instance, however, occurring among the vertical or nearly vertical strata; hence, perhaps, one cause of the prevalent error. The limestones have, it is true, disappeared, but the sequence of beds and of characteristic fossils is the same as at both places, although the inter-marine strata are considerably more dominant at Whitecliff. What then is the Bembridge limestone? The fossil contents at a glance show that it is the equivalent of the limestone of Sconce Point, which is there seen in a perfectly clear section, resting conformably on strata that lie upon the upper freshwater beds surmounting the inter-marine of Colwell Bay and Headon Hill. At Sconce, too, among other very slight remains of the marls surmounting the limestones, may be found the characteristic fossils of the lower portion of the thick and important marls capping the limestone at Bembridge. These same marls are exposed at low water in complete succession along the shore below Hempstead Hill to the east of Yarmouth, and are there seen to rest upon the limestone of Hempstead Ledge, characterized in like manner by the peculiar fossils of the Sconce, Bembridge, and Binstead limestones. Above the highest of the Bembridge marls we find at Hempstead a fresh series of beds resting, piled up in succession so as to form the entire thickness of the central portion of Hempstead Hill, and characterized by a fresh set of fossils. Thus do we find that the fluvio-marine Eocenes of the Isle of Wight are more than twice as thick as they have hitherto been regarded, and that the additional beds are of even greater geological importance than those hitherto recognized.

I venture to propose the following classification and nomenclature for the entire assemblage of fluvio-marine beds of older Tertiary date preserved in the Hampshire basin; the divisions are enumerated in descending order:—

A. *The Hempstead Series.* (Fig. 1, *a.*)

The thickness of this division is at least 170 feet. Throughout the beds composing it, three fossils, viz. *Cyrena semistriata, var.*, *Rissoa Chastelii*, and *Melania fasciata*, prevail. The second of these is not found lower down. All the species of *Cerithium*, besides many more mollusks, the *Cyprides*, and apparently also the vertebrata (especially *Hyotherium*), and plants found here are peculiar to this group. It may be subdivided into four sections, viz.—

a. The uppermost or *Corbula* beds; marine sands and clays containing *Corbula pisum*, and another species, *Ostrea callosa?*, *Ceri-*

thium subcostellatum, a small *Cytherea, Cyrena semistriata,* and a *Natica.*

b. The upper Hempstead freshwater and estuary marls and carbonaceous clays.—*Cerithium plicatum,* accompanied by *C. elegans* and *tricinctum*?, abounds in the brackish water portion of these beds, and *Paludina lenta,* along with species of *Limneus, Planorbis,* and *Unio,* in the freshwater strata. They pass below into unfossiliferous variegated marls.

c. The middle Hempstead freshwater and estuary marls.—These are distinguished by the presence of vast numbers of *Melania fasciata,* and alternate with beds filled with *Paludina lenta,* and cypridiferous clays. Seed-vessels are also very abundant. These beds likewise pass below into variegated marls. The lowest bed is a brackish water band of *Cyrena semistriata,* mingled with peculiar *Cerithia* and a remarkable *Panopæa.*

d. The lower Hempstead freshwater and estuary marls.—These are distinguished by the presence of *Melania muricata* and a peculiar *Melanopsis,* a new *Modiola,* peculiar small univalves, cyprides, and plant remains. Its lowest bed is a strong carbonaceous stratum, 3 feet thick, to which I have applied the name of "Black band." It is in this bed that the *Rissoa Chastelii* commences to appear.

The seed-vessels of *Chara medicaginula* and *C. helicteres,* not those so-called in British papers, but the true Brongniartian species, characterize the Hempstead series. The superficial area occupied by this division is very small.

B. *The Bembridge Series.* (Figs. 1 & 3, *b, c.*)

The beds of this division attain a thickness of more than 100 feet. They are widely spread and well-preserved. They consist of marls, clays, and limestones of freshwater, brackish, and marine origin. *Cyrena semistriata,* var. *antiquior,* ranges through the beds, but is not found lower down. *Paludina lenta, Melania muricata,* and *Melanopsis carinata* are also widely and abundantly distributed through them. This section may be subdivided as follows:—

a. Upper Bembridge marls, distinguished by the abundance of *Melania turritissima,* n. s.

b. Lower Bembridge marls, characterized by the abundance of a *Cerithium,* possibly a variety of *C. mutabile, Cyrena pulchra, Cyrena obovata,* var., and *Cyrena obtusa,* n. s. Remains of *Trionyx* are frequent in these beds.

c. Bembridge oyster-beds.—Green marls and sandy bands, in many places abounding with *Ostrea,* sp. ?, accompanied by peculiar *Cerithia, Mytili,* an *Arca,* a *Nucula,* &c.; the univalves mostly in the condition of casts.

d. Bembridge limestones.—Compact cream-coloured limestones alternating with shales and marls. Land-shells (most of them described by Mr. Edwards) are common in this limestone in all places, but are especially abundant at Sconce. The *Bulimus ellipticus* is one of its most generally distributed and best-known testacea. One of the bands, and a very constant one, is filled with a little globular

Paludina. At St. Helens *Cyclostoma mumia* is frequent. Of its freshwater pulmonifera, *Limneus longiscatus* and *Planorbis discus* are the most abundant and generally distributed species. The latter takes the place of the *Planorbis euomphalus* of the Headon series. *Chara tuberculata* is the characteristic gyrogonite. From these beds, especially at Binstead near Hyde, have been procured the remains of *Anoplotheria*, *Palæotheria*, and other mammals, many of them specifically identical with species of the gypseous series at Montmartre.

C. *The St. Helens Beds.* (Figs. 1 & 3, *d.*)

These lie between the Headon series proper and the Bembridge limestones. They are very variable in mineral character and thickness on the western side of the island, consisting entirely of about 60 feet of soft marls and shales, whilst between Ryde and St. Helens they thicken and assume the forms of strong freestones, sandstones, and loose sands; the first constituting an excellent and much-used building-stone. These beds are of fresh and brackish water origin. They contain numerous remains of mollusks, chiefly *Paludinæ* and *Melaniæ*, some of the latter peculiar to the beds; abundance of a carinated *Melanopsis*, and peculiar *Cyprides*. *Chara Lyellii* is the gyrogonite of this limestone band, which on the eastern side of the Isle of Wight divides the upper or Nettlestone beds from the lower division, or St. Helens sands.

D. *The Headon Series.* (Figs. 1 & 3, *e, f.*)

These beds are 170 feet thick, or thereabouts. They are seen best at Headon Hill and Colwell Bay, at Whitecliff Bay, and their lower divisions only at Hordwell. Everywhere *Planorbis euomphalus* characterizes their freshwater bands, accompanied by peculiar *Limnei*. *Potomomya plana* and *Cerithium cinctum* abound in the brackish water belts; and *Venus incrassata*, accompanied by many sea-shells, some peculiar, more of them common to the Barton series, occurs in the marine division. The group may be subdivided into three sections, all however more intimately connected by their fossils than the subdivisions of the higher series are among themselves.

a. The Upper Headons.—These form the greater part of what was usually termed the Upper Freshwater, and in Headon Hill were confounded with the superincumbent beds of the St. Helens series. The strongest masses of freshwater limestone in Headon Hill belong to this section, but a little way to the north they thin out considerably, and are represented in the Whitecliff Bay section by a few very thin and inconspicuous sandy concretionary bands. It was the strength of these and the limestones of the lower beds at Headon Hill that seems to have misled former observers into the belief that all the conspicuous limestones in the island belonged to the Headon series. The upper Headon beds consist in their highest part of brackish water bands abounding in *Potomomyæ* and a large variety of *Cyrena obovata*. At Cliffend they contain a *Cyrena*, which, though usually regarded as *C. pulchra*, appears to be distinct from

that fine species. Great numbers of the *Potamides margaritaceus* of Sowerby occur in these beds. The shells of the freshwater limestones are the same as those of the Lower Headons, with the exception, perhaps, of a large *Paludina* and the so-called *Bulimus politus*. *Melania muricata* abounds.

b. The Middle Headons.—This is what is usually called 'the Upper Marine.' At Headon Hill this division is mainly brackish, although Oysters, *Cytherea incrassata*, *Nucula deltoidea*, *Natica*, and *Fusus*, are sufficiently common. Immediately above and below, or rather forming the uppermost and lowermost portions of this section, are brackish water beds abounding in *Potamides ventricosus*, *P. concavus*, and *P. cinctus*; also in *Neritinæ* and *Nematuræ*. A little way off, at Colwell Bay, a marine character is assumed by the same bed, and large banks of Oysters are seen, with numerous marine shells, many of them of Barton species. It was this difference between the conditions at Headon Hill and Colwell Bay that misled M. Hébert. Judging from detailed sections, especially those published by the Marchioness of Hastings and Dr. Wright, the marine character is fully maintained, though in beds of a very inferior thickness, at Hordwell. Respecting that locality, however, there is a serious discrepancy in the statements of the describers. The section made by Lady Hastings appears to me to be the most correct, and to agree most accurately with the arrangements of the beds on the opposite side of the Solent. At Whitecliff Bay the marine character of the Middle Headons is still more extensively developed, and the thickness of purely marine deposits much greater than westward.

c. The Lower Headons consist of fresh and brackish water beds, abounding in fossils for the most part identical with those in the upper division. At Headon Hill and Colwell Bay there are strong limestones in this part of the series, but at Whitecliff all the beds are clays and marls. They are more varied at Hordwell, where the greater part of the fluvio-marine beds there seen belongs to the Lower Headons. In them at that locality numerous remains of Vertebrata have been found, especially by the Marchioness of Hastings, Mr. Searles Wood, and Mr. Falconer; and all the species appear to be peculiar and distinct from those in the Bembridge and Hempstead series, a fact to which attention was called strongly some years ago by the noble lady just mentioned, before the geological differences of the strata themselves had been suspected.

The lower beds of the Headon series rest upon the Headon Hill sands. No fossils have hitherto been recorded from these beds or the Isle of Wight. At Whitecliff Bay, however, though to all appearance barren, they are highly fossiliferous, containing abundant impressions of marine shells apparently of Barton species. The shelly matter has entirely disappeared, and, owing to the loose and friable condition of the sands, the specimens are quite untransportable.

These sands rest on the Barton clays, the relations of which at

each end of the Isle of Wight can now be made out very clearly, the bands of peculiar Nummulites having been found in the course of my work in Whitecliff even as in Alum Bay.

The Barton series is distinctly linked with the Middle Headons by not a few fossils. The relations to the marine beds of the Bembridge series are not so evident, but, strange to say, they are clearly enough shown to exist with the uppermost marine beds of all those that cap Hempstead Hill, in which the most plentiful fossil is a Barton *Corbula,* accompanied by a Barton and Headon *Natica.* The connection between the Headon, St. Helens, Bembridge, and lower portion of the Hempstead beds is maintained without a break by the well-marked *Melania muricata,* whilst *Melania fasciata* links all the series still more completely. *Cyrena obovata* ranges through the Headon, St. Helens, and Bembridge series, mingling in the latter group with *Cyrena semistriata,* which ascends to the upper division of the Hempstead group. *Paludina lenta* ranges through all.

The differences are most strikingly marked by the species of *Cerithium* and by the land and freshwater shells. The *Charæ* of the different groups appear also to be very distinct. The distinctness of the Vertebrata found in each division has already been noticed.

There is evidently no break in this series of deposits, and it would be harsh and forced to place one portion of them in the Eocene and another in the Miocene, as has been generally done on the Continent. In the Isle of Wight we have really the true clue to their relations clearly exhibited in unmistakeable and perfect sections. The importance of this clue in its bearing on Continental geology may probably be estimated very highly. In the accompanying table I have endeavoured to indicate the probable relations of the Isle of Wight section to some of the principal Eocene groups of the Continent and Mediterranean. As we might expect, a great portion of our fresh and brackish water beds is represented abroad by marine strata. Certain bands of well-marked fossils seem, however, to be so widely extended that we are enabled to indicate very definite horizons. Perhaps the most constant is the zone of *Cerithium plicatum*; well-marked among the tertiaries of France, Belgium, and Germany; and equally well-marked in the Isle of Wight. The relations of that zone to the marine beds containing *Pecten laticostatus* and gigantic Echinoderms, as seen in the south-west of France, enable us to fix the position of the Maltese and other Mediterranean tertiaries hitherto classed as Miocene, and thus to obtain a key to one of the most widely-spread and well-marked tertiary formations in the old, and apparently also in the New World.

Upper and Middle Eocenes of the Isle of Wight, with their probable foreign equivalents.

		Paris Basin.	Belgium.	Mayence.	Vienna.	S.W. of France.	Mediterranean.
UPPER EOCENE.							
A. Hempstead Series. 170 feet.	a. Upper or Corbula beds.	0 ?	Rupelian or Upper Limburg.	0	0	?	
	b. Middle	Calcaire lacustre supérieur.	Middle Limburg or Upper Tongrien.	Upper Brown-coal & Cerithium-kalk.	Lower division of Vienna tertiaries.	Faluns jaunes of Dax.	
		Grès de Fontainebleau.	....	Marine beds	....	Molasse ossifère.	Maltese beds; also in Corsica, Greece, Crete, Cerigo, S. of Spain, Portugal, Azores, and N. of Africa.
	c. Lower	Marnes marines?	Lower Limburg or Lower Tongrien.	....	....	Calc. à Astéries.	
B. Bembridge Series. 110 feet.	a. Upper or Bembridge marls.	....	0 ?	....	....	Molasse de Fronsadais and associated beds. (brace)	
	b. Middle or oyster beds.	Gypsiferous marls and Calcaire lacustre moyen. (brace)	0 ?	....	....	Molasse de Fronsadais and associated beds. (brace)	
	c. Lower or Bembridge limestone.	Gypsiferous marls and Calcaire lacustre moyen. (brace)	0 ?	....	....	Molasse de Fronsadais and associated beds. (brace)	
MIDDLE EOCENE.							
C. St. Helens beds 60–100 feet.		....	....	....	....	0 ?	
D. Headon Series. 180 feet.	a. Upper	Grès de Beauchamp. (brace)	?				
	b. Middle or "Venus" beds.	....	....	....	....	0 ?	
	c. Lower	Upper Calcaire grossier. (brace)					
E. Headon Sands (Upper Bagshots?) 100–200 feet.		Upper Calcaire grossier. / Middle Calcaire grossier. (brace)	....	....	....	0 ?	
F. Barton Series 300 feet.		Middle Calcaire grossier. (brace)	Laeckenien	....	....	0 ?	
G. Bracklesham Series 700 feet.		Glauconie grossière.	Bruxellien	....	....	Calcaire à orbitolites.	

2. *On a* Freshwater Deposit *in the* "Drift" *of* Huntingdonshire. By the Rev. H. M. De la Condamine, M.A., F.G.S.

In the Cambridge Philosophical Transactions for 1844, Mr. Brodie noticed the occurrence of recent species of land and freshwater shells, associated with the bones of extinct mammalia, in the marl and sand of the drift near Cambridge. The object of the present paper is to describe a very similar deposit in the valley of the Ouse, between St. Ives and Huntingdon.

The district consists of Oxford clay, capped by a variable covering of boulder clay (the "brown clay" of Prof. Sedgwick), which is frequently concealed in the low grounds by the ordinary flint-gravel of the eastern counties, this again underlying the modern alluvium (see fig. 1). The gravel is worked at Hemingford Abbots, and where the railway crosses the Ouse the section shown in fig. 2 is exposed.

The surface of the Oxford clay, at the bottom of the pit, is encumbered with concretions and fossils of that formation, and supports numerous boulders of granite, gneiss, trap, sandstone, mountain limestone, oolite, flint, &c., some rounded, others perfectly angular, and reaching 3 feet in diameter. No scratches are observable on any of them, but their form, magnitude, and variety at once refer them to glacial action.

On the stratum of boulders rests a coarse gravel, not varying from the ordinary flint-gravel of the eastern counties, with abundant fragments of the older rocks, and containing, as usual, mammalian remains. I succeeded in obtaining portions of Bos, Sus, Equus, and Red Deer. Many of the flints are scarcely waterworn and retain their chalky coating; others are perfectly waterworn, though none present the appearance of eocene pebbles. Most of them are yellow throughout, but I have examples of every intermediate state of decomposition, from that to the black flint apparently fresh from the chalk; yet the former are not invariably the most waterworn. It is evident, therefore, that decomposition is not a measure of the *time* of exposure only, but must depend upon the *circumstances* of exposure*. The crevices of the flints sometimes bear remains of Serpulæ, and I have not unfrequently observed a calcareous incrustation resembling that which is common on the sea-shore; but no shells or other marine remains have been noticed in any part of this widely spread gravel. I cannot therefore but think that it is not the result of ordinary marine action, and that we must refer it to a sudden and violent agent, hurrying along the materials of distant and various coast-lines, and partly confusing them with the still more heterogeneous boulder accumulations. The presence of the remains of land quadrupeds must, I think, be referred to some such desolating action, their remarkable abundance, in the utter absence of marine exuviæ, being improbable in an ordinary marine deposit, and without parallel in any earlier formation.

On the gravel rests a bed of coarse sand, diagonally stratified, and

* A notable example of this is the Shooter's Hill gravel, which consists of well-rounded but discoloured pebbles, with a mixture of black uninjured eocene pebbles.

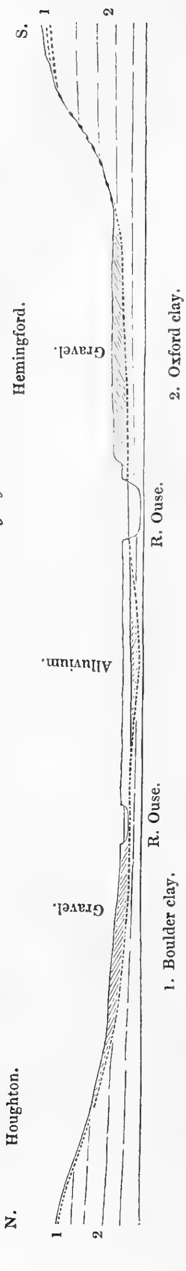


Fig. 1.—*Section across the Valley of the Ouse.*

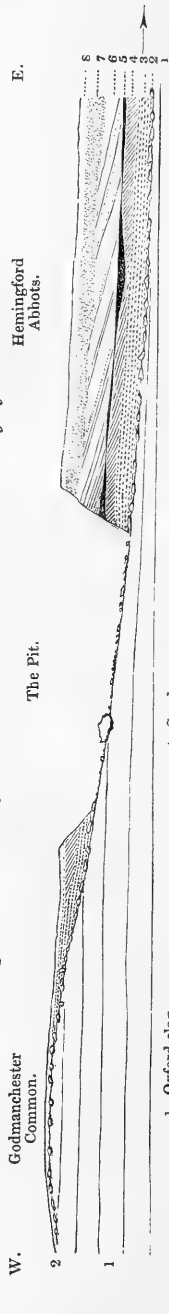


Fig. 2.—*Section of the Freshwater Beds in the Valley of the Ouse.*

1. Oxford clay.
2. Boulders, 2 feet.
3. Coarse gravel with bones, 2 feet.
4. Sand .... } 2 feet.
5. Marl with shells }
6. Sand with shells, 3 feet.
7. Fine gravel, 1 foot.
8. Sandy soil with a few flints, 2 feet.
→ Level and direction of the Ouse.

containing bones at the base (according to the workmen). Hollows in the surface of this bed are filled with marl, in which are the following land and freshwater shells, with fragments of vegetable substances, and an indeterminable fragment of bone:—

*Pupa marginata.	Bithinia tentaculata.
*Helix hispida (var. concinna).	Planorbis marginata.
*Valvata piscinalis.	—— spirorbis.
Succinea oblonga.	*Cyclas cornea.
Limneus pereger.	*Pisidium amnicum.

* These occur also in the upper bed of sand.

Nearly five-sixths of the specimens which I procured were *Pupæ*,—a remarkable numerical preponderance which appeared likely to throw light on the precise circumstances of the deposit. I therefore gathered up indiscriminately the shells left on the bank of the river after a slight flood, and found that that was the exact ratio of terrestrial to aquatic shells; and on examining the recent alluvium, I found land shells entirely wanting at the base, rare in the middle, but exceedingly abundant at the top. The inference seems to be, that their presence in large numbers indicates a level a little above the ordinary height of the water; and this might well be anticipated when we consider that a land-flood will sweep off from the meadows the dry and empty shells, while by drowning others it prepares a fresh supply for its successor. I conclude then that the seam and patches of marl indicate such a level, and were accumulated in pools bordering on a river which discharged itself through the present valley. This view is favoured by the direction of the diagonal lamination† of the sand both above and below the marl: see section 2. In the upper bed of sand are a few shells of the species marked with an * in the preceding list. The "stratula" of coarse sand pass upwards indistinctly into the unstratified bed of fine gravel; and on the latter rests 2 feet of sandy soil with a few flints dispersed in it.

I interpret the phenomena of this section thus: after the deposit of the rough gravel, a river met the sea probably not much below this point, and deposited the lower bed of sand, till either this filling up, or a slight movement of elevation, produced a temporary subaërial condition. The marl was then formed from the decomposition of shells, and washed into its present position out of pools higher up the valley, as would appear (1) from its amorphous condition while containing perfect shells; (2) from its impure state and mixture with loam; and (3) from the absence of calcareous rocks in most of the country through which the river would run. A movement of subsidence then commenced, during which the river again threw down sand and shells. And here it must be observed that the fall of the present river between Huntingdon and St. Ives is 3 feet per mile, which would give a sufficient velocity for the transport of sand, although, from artificial interference with its course, the Ouse deposits only loam. The subsidence continued until this spot reached

† May not the word *stratula* be coined to describe those smaller subdivisions of strata which are frequently oblique? I should then say that the stratula here dip to the east.

the sea-level, and the result was the disturbance of the upper part of the sand and the deposit of the fine gravel. Opening however to the east, with much shelter from the rising ground in that direction, the coast action would not be violent; but the tidal action would be considerable, for Hemingford would be the entrance to an inlet of some magnitude, St. Neots being only 20 feet above the base of this section. Hence the river deposits would be for the most part swept away, and when the subsidence again gave way to elevation, the valley would have nearly its present form.

The surface soil, corresponding I presume with what Mr. Trimmer has called the warp of the drift, may have resulted from river action in the last intermediate state; but after the disturbing action of plants, worms, and man, it is perhaps vain to endeavour to trace its precise origin. Whether the same changes of level will explain the phenomena of the valleys of the Cam and the Nar or of the Thames itself, I leave to abler hands than mine to determine.

May 18, 1853.

Lord Moreton, M.P., was elected a Fellow.

The following communications were read:—

1. Palichthyologic Notes. No. 4.—*On the* Affinities *of the* Genera Tetragonolepis *and* Dapedius. By Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. &c.

[Plate XI.]

Before entering upon the descriptions of the many new species of fossil fishes which have accrued to the subfamily *Lepidoidei homocerci* since the publication of the 'Poissons Fossiles,' it will be necessary to consider the affinities of the genera *Tetragonolepis* and *Dapedius*, arranged by Prof. Agassiz at the head of this subfamily, with reference both to the relations they have to each other, and to the family in which they are placed. Both these genera are adopted by Agassiz, the former from Prof. Bronn, the latter from Sir Henry de la Beche, but (although impressed with the conviction of the existence of the two types) the Professor found the greatest difficulty in defining the demarcation between them, and assigning to each its own generic attributes. Bronn's genus contained but one species, and that a unique specimen from the Lias of Neidingen, in the cabinet of Baron Althaus at Durheim, while *Dapedius* comprised all the fossil fishes discovered in England that had any resemblance to the figure of *Dapedius politus* published in the Geological Transactions. Among the latter he found that some had the crowns of the teeth single, while in others they were more or less notched, and he seized upon this as the criterion between the genera, ranking all the single-

toothed species with *Tetragonolepis* and the remainder with *Dapedius*. All the previously assigned differential features having failed, he adopts this as "le seul caractère constant qui les distingue*." In the absence of this distinctive character, it is impossible to determine to which of the two genera any given specimen may belong. For instance, two British species from the Lias of Barrow on Soar, assigned by Agassiz to the *Tetragonolepides*, are proved by the recent discovery of the teeth to belong to the *Dapedii*, if the discrimination of the genus turns upon the form of the teeth. But, alas for the constancy of fishes' teeth! a specimen came into my hands not long ago having a combination of the two forms of tooth, the principal sets in each jaw being conical and single-pointed, and all the subsidiary teeth bifurcate (Plate XI. fig. 1). Having my attention thus directed to this point, I have since found a specimen of *Dapedius punctatus* in Lord Enniskillen's collection which has both forms of tooth in the principal series in both jaws (Plate XI. fig. 2). The conclusion therefore is irresistible, that the form of tooth is a character too capricious to be relied upon in this instance as a generic definition.

This much had I written before my arrival in London, and after a careful review of the whole subject had determined to recommend the union of the two genera under Sir Henry de la Beche's title *Dapedius*, that having the claim of priority over *Tetragonolepis*. In consequence, however, of the fortunate discovery by the Rev. Mr. Brodie of several specimens of a small fish belonging to this group in the Upper Lias of Gloucestershire, I am now enabled to throw considerable light, not only on the generic but on the systematic relations of these curious ichthyolites, and to advocate the propriety of retaining the genus *Tetragonolepis*, as being wholly distinct from *Dapedius*, and belonging most probably to a different family.

I was struck at first sight with the strong resemblance Mr. Brodie's fish bore to the original specimen of *Tetragonolepis semicinctus*, on the examination of which Bronn founded the genus. On referring to the description and figure given by him in the 'Jahrbuch für Mineralogie,' &c. p. 22, 1830, my opinion was confirmed as to the generic identity, although specific differences were perceptible. In November 1841, Count Münster, in a letter to the editors of the 'Jahrbuch†,' alludes shortly to a small species of *Tetragonolepis*, from the lias of Wurtemburg, which he at first took for a specimen of *Tetragonolepis semicinctus* of Bronn, but finding the abdominal scales to be serrated, he named it *Tetragonolepis subserratus*. Having received from the late Dr. Hartmann of Göppingen several specimens of the latter species, from the lias of Banz and Ohmden, I have been able to make a close comparison between these and Mr. Brodie's specimens, and find an important character constant in all, in the mode of articulation of the scales, together with other common features of much significance. One of the reasons which induced Prof. Bronn

* Poissons Fossiles, vol. ii. p. 181.

† Jahrbuch für Mineralogie, 1842, p. 97.

to consider his specimen irreconcileable with the genus *Dapedius*, was the absence of the peculiar processes by which the scales of most of the Lepidoid fishes are locked to each other. Agassiz considers him misled in this respect, since the scales are only seen outwardly, in which case this characteristic mechanism would be concealed by the adjoining scales; but he does not deny the value of the character, should such be shown to exist. In fact, experience has proved this to be one of the most valuable and trustworthy features with which we are acquainted in the study of fossil ichthyology. On comparing the scales of Mr. Brodie's species, which I have named *Tetragonolepis discus*, with those of *Tetragonolepis subserratus*, with a view of determining this point, it not only appeared that the ordinary lepidoid mechanism was not present, but that the arrangement and articulation of the scales coincided precisely with that found in the *Pycnodontidæ*, and in that family alone.

This peculiar structure (Plate XI. fig. 3) is thus described in a notice I communicated to the Society in 1849, on the affinities of the genus *Platysomus*:—"Each scale bears upon its inner anterior margin a thick solid bony rib, extending upwards beyond the margin of the scale, and sliced off obliquely above and below, on opposite sides, for forming splices with the corresponding processes of the adjoining scales. These splices are so closely adjusted, that without a magnifying power, or an accidental dislocation, they are not perceptible. When *in situ* and seen internally, these continuous lines decussate with the true vertebral apophyses, and cause the regular lozenge-shaped pattern so characteristic of the Pycnodont family."

This description is precisely applicable to the specimens I have alluded to; in short, the dermal characters of *Tetragonolepis* are closely allied to, if not identical with, those of the *Pycnodontidæ*. In some respects the lepidoid characters prevail: the form and position of the dorsal and anal fins, the square tail, and the arrangement of the opercular bones are very similar to these conditions in *Dapedius*. The pectoral fin is situated opposite the junction of the operculum with the suboperculum, a higher position than is found either in the *Dapedioids* or the *Pycnodonts*; the lateral line is straight, and pierces the row of scales immediately above the spinal column; the head is exceedingly small; the jaws are short and solid, and have not the prognathic character so prevalent with the *Pycnodonts*; the front teeth are elongated cones with single points, one row alone is visible. The true position of this genus will depend on the discovery of the interior of the mouth, which is not seen in any of the specimens I have examined. If it should prove that it is furnished with tritoral teeth, there will remain no doubt of the propriety of assigning it to the *Pycnodont* family; in the mean time it must be considered as having close affinities with it, and presenting a transitional form between that family and the *Lepidoidei*. This genus then will comprehend the typical species *Tetragonolepis semicinctus*, Bronn, *Tetragonolepis subserratus*, Münster, *Tetragonolepis discus*, from the lias of Gloucestershire, and a second new species from the lias of Ohmden, which I propose to name *Tetragonolepis cyclosoma*.

It may not be out of place here, to consider shortly the bearing of the foregoing remarks upon the general arrangement of this family. The position assigned by Prof. Agassiz to the genera *Tetragonolepis* and *Dapedius* was mainly owing to the proximity of the flat-bodied genus *Platysomus*, at the brink of the heterocerque ganoids; but the removal of the latter genus to the *Pycnodont* family breaks up this link of affinity at the commencement of the family, to add it at the close. Moreover, the discovery of the American genera *Catopterus* and *Dictyopyge*, the former a heterocerque, the latter a homocerque form, renders the transition from the genus *Palæoniscus* to *Pholidophorus*, perhaps the two most typical representatives of their respective families, both gradual and natural. Taking then *Pholidophorus* as the starting-point, we find the affinities of the other genera assuming two diverging lines, the one passing by *Nothosomus*, *Notagogus*, and *Ophiopsis* to the Sauroid, the other by *Lepidotus*, *Semionotus*, *Amblyurus*, *Dapedius*, and *Tetragonolepis* to the Pycnodont family.

Since the foregoing communication was forwarded to the Geological Society, I have fortunately found a specimen in the British Museum, which furnishes the only link wanting in the evidence to substantiate the genus *Tetragonolepis* as a member of the *Pycnodont* family. This is a large and undescribed species from the lias of Boll, having not only the dermal characters above alluded to, clearly, distinctly, and most unmistakeably displayed, but showing also the character of the dentition. In this respect it has a very close resemblance to the genus *Microdon*, but the masticatory apparatus is even smaller in proportion to the size of the fish than it is in that genus.

Description of Species.

Family Pycnodontidæ, Agassiz.

Genus Tetragonolepis, Bronn.

1. T. semicinctus. Described by Prof. Bronn in the 'Jahrbuch für Mineralogie,' &c. 1830, p. 22: 'Poissons Fossiles,' vol. ii. p. 196, pl. 22. figs. 2 & 3.

Locality. Lias of Neidingen.

2. T. subserratus, Münster. Described by Count Münster in the 'Jahrbuch für Mineralogie,' &c. 1842, p. 97. I am very much inclined to believe that this species is identical with the former. The only character assigned by Count Münster for its specific distinction, is the serration of the carinated series of scales on the abdomen. This, however, appears to be constant in all the species of the genus I have seen, and may, for anything Bronn states to the contrary, obtain also in Count Althaus' specimen. Indeed he describes the simple series of projecting ventral scales as reminding him of the appearance of the "dentelure abdominale" in the genus *Pristigaster*. This seems a common fish in the lias strata of Banz and Boll. There are specimens

in the British Museum, as also in the collection of the Earl of Enniskillen and in my own.

3. T. CYCLOSOMA, mihi. This is a smaller species than the foregoing. The body is about the size of a five-shilling-piece and almost as round. The head is small, and the facial line coincides with the general circular outline of the body. In *T. subserratus* the jaws project beyond the confines of a circle described in like manner. The depth of the body below the vertebral column is three times as great as the dorsal portion above the column. The thoracic arch in this, as in the other species, has a sigmoid flexure quite peculiar, the lower half below the insertion of the pectoral fin sweeping downwards and backwards with a considerable curve; the fins and tail are all deficient in the specimens I have seen; the scales are seen internally, the articulations characteristic of the family being very evident. The single line of ventral scales is finely serrated, as in the preceding species.

Locality. Lias of Banz.

The only specimens I have seen are in the collection of the Earl of Enniskillen and in my own.

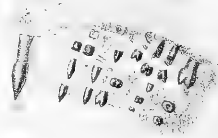
4. T. DROSERUS, mihi. This is the specimen alluded to in the previous part of this memoir as being in the National Collection. It is a fine species, nearly as large and much resembling in form the Kupferschiefer *Platysomi.* The body is not nearly so deep in proportion to the length, as in the other species. Most of the scales are displayed internally, showing the articulating rib to be very strong. Some are removed, leaving their impressions on the shale; and some few show the peculiar character of the surface, from which I have taken the specific name. The appearance is granulated, but the granules of ganoine scattered on the surface have so much more lustre than the general superficies of the scale, that they resemble a fine sprinkling of liquid. The teeth are very small compared with the size of the fish (Plate XI. fig. 4); the anterior ones are conical, as in the genera *Gyrodus* and *Microdon,* and the succeeding ones are short and thick, with a corrugated crown resembling the tritoral teeth in the latter genus. The single row of abdominal scales is present here, as in all the species of all the genera of the Pycnodont family, and are coarsely serrated. This row of scales constitutes an important part in the mechanism of the dermal skeleton of these fishes, for from each of them originate the two strong ribs which traverse each row of scales and link them together; so that in fact each of them is the keystone of an inverted arch similar to the keel of a ship. This mechanism is completed by a corresponding row of scales along the back in most of the Pycnodonts, but it is not well seen in any of the *Tetragonolepides* I have as yet examined.

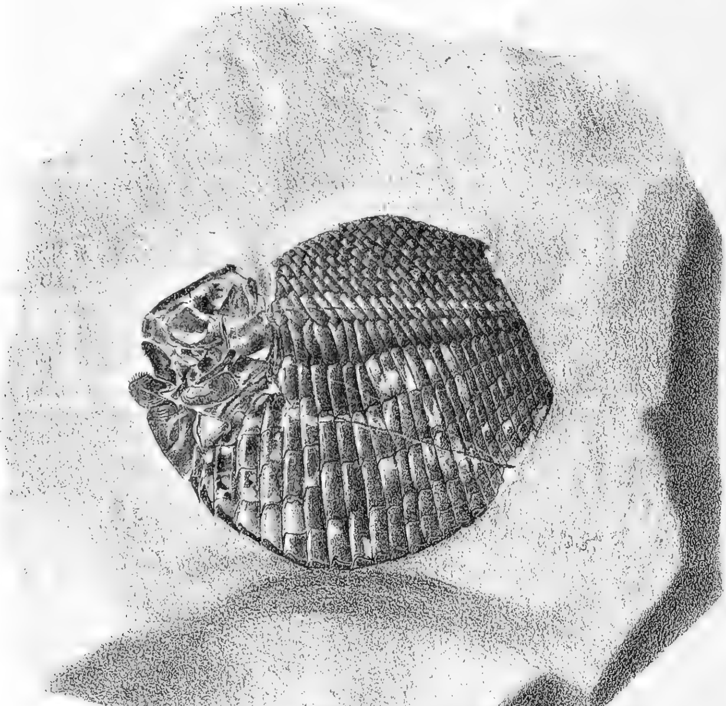
Locality. Lias of Boll.

5. T. DISCUS, mihi. This beautiful little fish (Plate XI. fig. 5) was discovered by the Rev. P. B. Brodie in the Upper Lias of Gloucestershire. The best specimen is perfect as far as the anal region with the exception of the fins, which are deficient. It shows

4. Teeth of Tetragonolepis droserus, magnified.

1. Teeth of Dapedius, magnified.





5. Tetragonolepis discus.

2. Teeth of Dapedius punctatus, nat. size

3. Scales of Tetragonolepis subserratus, inner view, magnified.

DAPEDIUS AND TETRAGONOLEPIS.

Jos. Dinkel lith.

Ford & West Imp.

the outer surface of the scales. A second specimen shows the inner surface with their characteristic articulations. The general form and outline of the fish correspond more closely with *Tetragonolepis cyclosomus* than with any other species of the genus. It differs from that species in the smaller diameter of that portion of the flank below the vertebral column, as compared with the dorsal portion, or that above the line of vertebræ; it also differs from that and the other species in the arrangement and relative proportions of the scales. The head is small and its profile semicircular; the opercular flap is singularly restricted in dimension, while the lower jaw and the branchiostegous apparatus are no less singularly expanded; the operculum and suboperculum are both remarkably small, but the interoperculum is comparatively large; the jaws are thick and broad, and furnished with an outer row of elongated conical teeth; the masticatory apparatus of the interior of the mouth is not seen; the lower jaw is especially remarkable for its great depth, so much so, that it resembles an oval plate rather than a member of the maxillary series; the angle between the lower jaws is closed by a pair of broad plates referable to the hyoid system, and these are succeeded on each side by a pair of expanded branchiostegous rays. Immediately behind and below the thoracic arch is a single strong carinated scale with a serrated keel, being the first of a series extending along the ventral margin as far as the commencement of the caudal fin. The vertebral column, as indicated by the elevation of the scales along its course, is straight; the scales in the row immediately above it are perforated for the transmission of the mucous secretion. Above the lateral line are six or seven rows of small rhomboidal scales, obliquely arranged and increasing in depth as they recede from the back. The number of scales in each series below the lateral line varies from five to six, the scales of the second and third rows being the largest; in those containing six rows the last scale is the smallest, but in those having only five, the scales vary little in dimensions; they are all coated with a layer of highly lustrous ganoine, having a slightly eroded character when examined through a lens: the margins are entire. The fins are unfortunately deficient in all the specimens, but the base of the pectoral fin is traceable in a higher position than is common in the *Pycnodontidæ*, it being nearly coincident with the union of the operculum with the suboperculum. We are indebted to the zealous researches of the Rev. P. B. Brodie for this interesting addition to our British Fossil fishes, who discovered it in the beds of the Upper Lias at Dumbleton in Gloucestershire.

DESCRIPTION OF PLATE XI.

Fig. 1. Teeth of *Dapedius*, magnified.
Fig. 2. Teeth of *Dapedius punctatus*.
Fig. 3. Scales of *Tetragonolepis subserratus*, inner view, magnified.
Fig. 4. Teeth of *Tetragonolepis droserus*, magnified.
Fig. 5. *Tetragonolepis discus*.

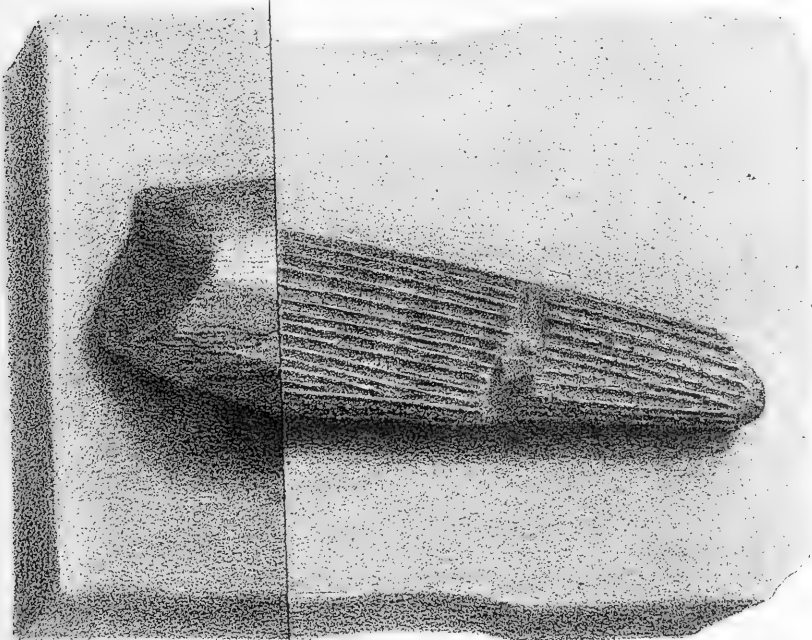
2. PALICHTHYOLOGIC NOTES. No. 5.—*On two new species of* PLACOID FISHES *from the* COAL MEASURES. By Sir PHILIP DE M. GREY EGERTON, Bart., M.P., F.R.S., F.G.S. &c.

[PLATE XII.]

SOME years have now elapsed since I first became aware of the occurrence of a large species of Cestraciont in the shale-beds of the Lanarkshire coal-field; but I have postponed from time to time the task of describing it, partly from an unwillingness to rush before the public, on the discovery of each new species, with inconsiderate haste in the general scramble for priority of credit, now, I regret to say, so much the vogue, but principally in the hopes that some cognate materials might come to light to render the communication more worthy of the time and attention of the Society. The recent discovery of a second species, and the increased and increasing interest which the researches of the last few years have imparted to the fauna of the Carboniferous epoch, may perhaps now be considered a sufficient justification for the present memoir, meagre though it be.

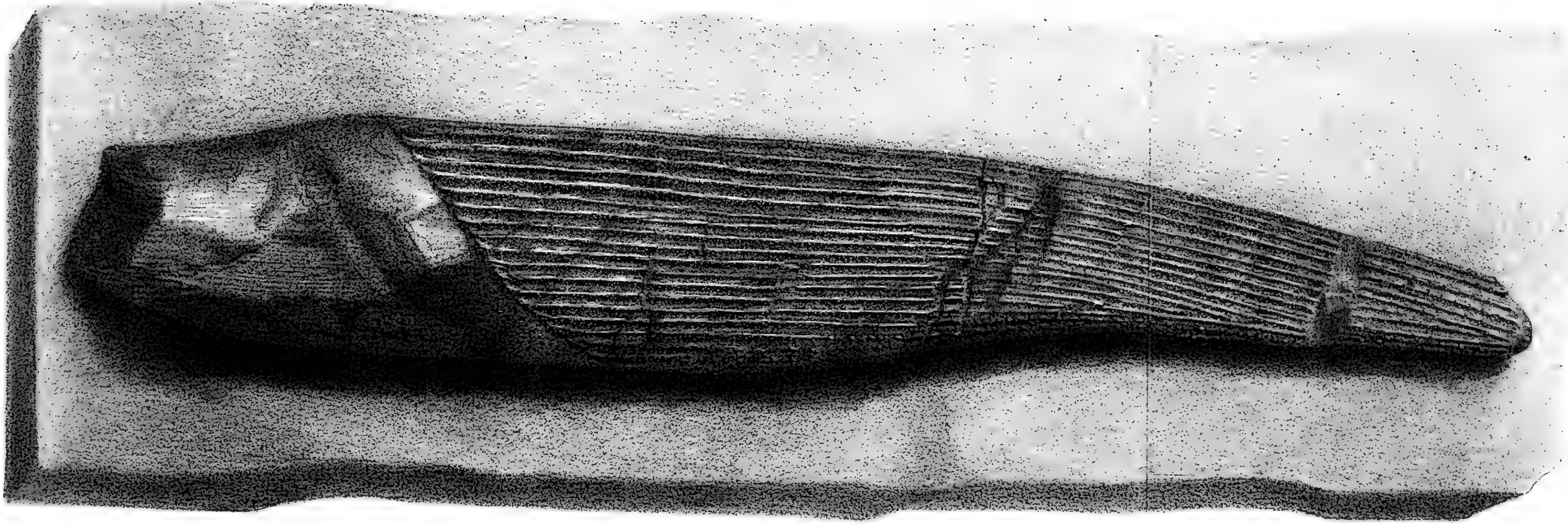
The first specimen which attracted my attention to this subject was a defence-bone discovered by a collector named Doran in the black shales of the Carluke district. This is now in the British Museum. Similar rays have since been found in several localities. The Museum of Practical Geology possesses specimens from the Talwyn works, near Mold in North Wales, in shale; and from Hady, near Chesterfield, in ironstone. And Lord Enniskillen and myself have several very perfect examples from the neighbourhood of Dalkeith, where they are associated with finer specimens of Gyracanthus spines than I have seen from any other locality.

CTENACANTHUS HYBODOIDES.—The most perfect specimen I have seen of this species (Plate XII.) is contained in a slab of black compact shale from the Dalkeith district. It measures $9\frac{1}{2}$ inches in length, 7 inches being external, and $2\frac{1}{2}$ inches imbedded in the integuments. The proportion of the latter to the former is smaller than is usual in the Ichthyodorulites of the Oolitic age. The greatest width of the spine is $1\frac{1}{2}$ inch. On quitting the body of the fish this spine is nearly straight for half its length; it is thence slightly recurved. The angle it forms with the line defining the integumentary investment is about 45°. The external portion is elegantly ornamented with frequent parallel longitudinal ridges, greatly resembling the characteristic ornamentation of the dorsal spines of the *Hybodi*. They are about eighteen in number at the base, but diminish to twelve at the apex. Those on the anterior and middle regions of the spine are continuous throughout its entire length, but the remainder die out as they reach the posterior angles. A double row of small tubercles, extending from the base to the apex on either side, defines the junction of the lateral with the hinder area of the bone. This tubercular character is traceable, but in a less degree, on all the longitudinal rays as they approach the extremity of the fin. I have



Jos Dinkel lith.

Ford & West Imp.



Jos. Dinkel lith.

Ford & West Imp.

CTENACANTHUS HYBODOIDES, Egerton
From the Coal shale, Dalkeith

seen no traces of the thorns or spines on the back of the fin common to all the *Cestraciontidæ* of the Oolitic period.

Ctenacanthus nodosus.—Lord Enniskillen has in his collection an Ichthyodorulite, found also in the Dalkeith pits, differing in several well-defined characters from the subject of the foregoing description. It is contained in a bed of sandstone grit, alternating with shale-beds, and full of vegetable remains and scales of *Megalichthys*. It measures 1 foot in length, of which 9 inches was external, and 3 invested by the integuments. The width at the line of demarcation between the two is 2 inches. The basal portion is comparatively short and broad, and has a wide internal cavity. The obliquity of the line between it and its external prolongation is more considerable than in the preceding species. The ornamented portion of the ray is devoid of the graceful outline which characterizes many of these fossils; it is short in comparison with its breadth, and contracts rapidly in diameter. The anterior profile is nearly straight for two-thirds of the entire length; it thence trends backwards with an abrupt and inelegant curve. The surface is ornamented with continuous longitudinal ribs or ridges, more or less constricted transversely, at irregular intervals; they agree in number with those of the preceding species. On the anterior portion they deviate so slightly from the uniform character prevalent in that species, that a fragment from this part of the fin might be confounded with it; but as they recede from the front they are more and more deeply and frequently contracted until they become broken up into distinct tubercles. This gives a knotted or moniliform character to the surface of the ray very different from that of *Ctenacanthus hybodoides*. The point of the ray is rounded and polished by friction, and the surface ornament for nearly an inch is obliterated by the same agent. This character is also found in the rays of *Asteracanthus*, and seems to indicate the more rocky parts of the ocean as the favourite habitat of these fishes.

On comparing the above with the genera described by Professor Agassiz, they most nearly resemble the characters assigned by him to the genus *Ctenacanthus*. This genus is common to the Carboniferous Limestone of Bristol and Armagh, and has been also found in the Old Red Sandstone, but has not hitherto been recorded as occurring in the coal-bearing strata. The progress of our knowledge of the relations of these Ichthyodorulites to the teeth with which they are associated has been very slow. The arguments deduced from the numerical proportions of certain forms of teeth to the rays found in the same strata cannot be relied upon, neither can any sound deduction be drawn from the relative sizes of the detached parts. The only conclusive evidence is the discovery of the conjunction of the teeth and fins in the same specimen. By this means we now know the fin-rays of *Hybodus*, *Acrodus*, and *Chimæra*; and I have recently seen in the collections of Mr. Catt of Brighton and Mr. Potter of Lewes specimens that prove the spine from the chalk named by Agassiz *Spinax major* to have belonged, not to a Squaloid fish, but to a Cestracion,

described by me under the name *Cestracion canaliculatus* in Mr. Dixon's 'Geology of Sussex,' page 365. Mr. Catt's specimen shows a dorsal spine and the vertebral column in conjunction with the teeth; and Mr. Potter's specimen shows the vertebral column and two spines, that belonging to the second dorsal fin being straighter and shorter than the anterior one. In commenting upon the probable connexions of the teeth and fin-rays of the Placoid fishes, hitherto discovered in the Carboniferous age, Prof. Agassiz conjectures that *Orodus* should be assigned to *Oracanthus*, and *Psammodus* to *Ctenacanthus*. The occurrence, however, of the latter genus of Ichthyodorulite in the coal-measures unassociated with teeth of the genus *Psammodus* would militate against this suggestion. It is more likely to have belonged to the genus *Pœcilodus*, which occurs in some abundance in the Coal-measures as well as in the Carboniferous Limestone of Bristol and Armagh.

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3. *On the* STRUCTURE *of the* STRATA *between the* LONDON CLAY *and the* CHALK *in the* LONDON *and* HAMPSHIRE TERTIARY SYSTEMS. By JOSEPH PRESTWICH, Jun., Esq., F.R.S., F.G.S.

PART II.—THE WOOLWICH AND READING SERIES.

[The publication of this paper is postponed.]

JUNE 1, 1853.

Count Alexander von Keyserling and Prof. L. de Koninck were elected Foreign Members.

The following communications were read:—

1. *On the* SOUTHERN TERMINATION *of the* ERRATIC TERTIARIES; *and on the Remains of a* BED *of* GRAVEL *on the Summit of* CLEVEDON DOWN, SOMERSETSHIRE. By JOSHUA TRIMMER, Esq., F.G.S.

THE present communication must be regarded as merely the opening of a subject to which I would invite the attention of those who have better opportunities of investigating it,—the search for traces of the Erratic Tertiaries in districts which have hitherto been deemed wholly free from them.

The southern termination of these deposits, both on the eastern and the western side of the island, is an interesting question involved at present in much obscurity. Their termination on the East will be

treated of in another paper. On the West they have a greater southern extension than has been assigned to them by high authorities. I have myself traced the Boulder-clay, with fragments of granite, Antrim chalk, and shells, nearly to St. David's Head; and, in travelling across the country, I have observed the rolled gravel of the Upper Erratics extending to the neighbourhood of Milford. In Ireland, the Ordnance brickworks at Youghal, in the county of Cork, were established on boulder-clay. If to this be added the well-known existence of grooved and scratched rocks at the southern extremity of the county of Kerry, it will be impossible to exclude any considerable area in Ireland or South Wales from the glacio-marine operations; and the boundaries which have been assigned to the boreal ocean, in order to explain the geological relations of the existing fauna and flora of the British Isles, will require considerable modification.

In the Valley of the Severn, the most southern locality yet recorded for shells and granitic detritus is about three miles south of Worcester*.

Sir Roderick Murchison has stated, that though boulders of northern origin diminish in quantity south of Bridgnorth and Wolverhampton, coarse gravel, composed of the same materials, is prolonged, like the tail of a delta, through Worcestershire, until it dies away in the fine gravel and silt of the Vale of Gloucester†. It is an important question in the history of these deposits, whether this dying-off arose from an original cessation, at that point, of the agencies which transported the northern detritus; or whether it is the result of denudation and re-arrangement. I hold the latter opinion, because it accords with the phænomena of denudation which I have observed along the main lines of drainage in South Wales, and which appear to be repeated on a larger scale in the Valley of the Severn. In such valleys the boulder-clay is rarely found, except near their upper portions and near the limits of that deposit as regards elevation above the sea. In their lower regions it occurs only as small broken patches; and extensive areas are either wholly free from the presence of the erratic deposits, or exhibit them only under their reconstructed form of rolled gravel at low levels. At the same levels, however, adjoining minor valleys are filled with boulder-clay, and large spaces between the great lines of drainage are covered by the sand and gravel of the upper erratics resting on boulder-clay. This would be very evident if I could have an opportunity of exhibiting the lost map of the Surface Geology of part of Cardiganshire and Pembrokeshire which I constructed for the Government Geological Survey, and to which I have so often referred.

In Rutter's 'Delineation of Somersetshire,' published in 1829, there is a sketch of the geology of the county which appears to be chiefly a compilation from various sources; but, as the authorities are not always cited, it is difficult to separate the compiled from the original

* Proc. Geol. Soc. vol. ii. p. 95; and Sil. Syst. p. 534.
† Proc. Geol. Soc. vol. ii. p. 333.

matter. In speculating on the general absence of diluvium, the author alludes to the probability of its being concealed by the extensive tract of alluvium, and mentions rolled gravel, containing fragments of all the neighbouring rocks, from the old red sandstone to the chalk, as occurring at the mouth of the Avon, associated with the bones of quadrupeds peculiar to the diluvial beds, and covered by peat. He speaks also of ridges of sand and shingle, provincially called "*batches*," rising through the alluvial deposits in several places, instancing as one of the most remarkable that on which the village of Yatton stands.

While recently engaged in constructing a map of the soils, subsoils, and substrata of Sir Charles Elton's estate, in the parish of Clevedon, I saw this gravel in the railway-cutting near the Yatton Station, but had no opportunity of examining the materials of which it is composed.

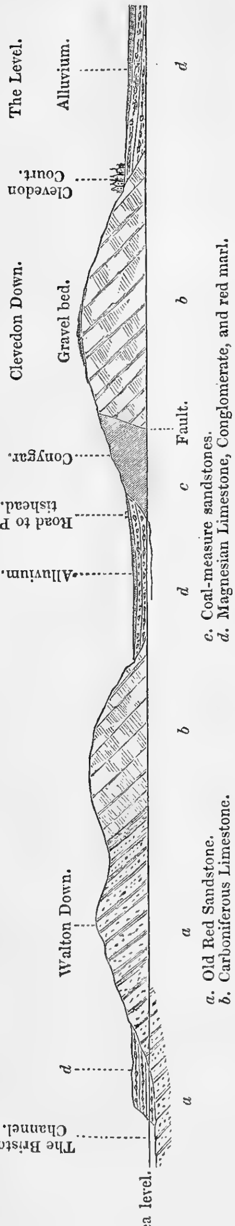
In the course of my survey of that estate, I was struck with two remarkable facts. The first was the general absence of erratic detritus; the second, a general uniformity in the composition of the soil, whether on the Carboniferous Limestone, the Coal-measures, or the Magnesian Conglomerate; a uniformity which seemed to indicate a blending, by aqueous operations, of the fine detrital matter of more than one formation, rather than the exclusive derivation of the soil from the rock on which it rests.

Of coarse extraneous matter it was long before I discovered any fragments large enough to be called pebbles, with the exception of a few rolled fragments of quartz and of limestone, at heights of about 100 feet above the sea.

In the alluvial clay, generally free from pebbles, I also found a few chalk-flints near the southern boundary of the parish, where it approaches the 'batch' or shingle-bed of Yatton. The bed of the stream called the Blind Yeo was described to me, by a labourer who had frequently scoured it, as containing many such pebbles. With respect to the soils, I found in them a great tendency to redness at all elevations, and on every rock. This colour, which appears to have been derived by means of the washing of water from some of the adjoining red formations, may be ascribed at low levels to the New Red,—at high levels to the red beds of the Coal-measure sandstones, or to the Old Red Sandstone of the parallel and neighbouring ridge of Walton Down. In either case it would indicate extensive aqueous operations.

The discovery of the remains of a bed of gravel on the summit of Clevedon Down (see fig. in the Postscript), at an elevation of about 300 feet above the sea, confirms these views, and throws much light on the derivation of the soils from other formations than those on which they rest. This gravel-bed is situated at the point where the lane through Norton Wood emerges upon the Down. Covering only a few square yards of surface, and not exceeding three feet in depth, it owes its preservation to the fact of its having been cemented by calcareous matter into a tufaceous conglomerate. Its materials are chiefly rolled pebbles from the different beds of Carboniferous Lime-

Section from the Sea near old Walton Church to the Level at Clevedon Court.



stone; but with them are associated other fragments, which appear referable to formations foreign to the ridge on which the gravel rests.

A few specimens, collected hastily the evening before I left Clevedon, accompany this paper. They are submitted to the examination of those geologists who are better acquainted with the rocks of this neighbourhood than I am.

Neither pebbles of granite nor marine shells having yet been found in this gravel, it cannot be absolutely identified with the erratic tertiaries. There is no æra, however, to which it can be referred with so much probability as the Pleistocene; because there is no other during which we have evidence of the transportation of detritus over great inequalities of surface, and the Walton and Clevedon ridges acquired their present insulated character at an epoch so remote as the Permian, as is evident from the Magnesian Conglomerate which surrounds them.

Postscript.—It has been suggested by those whose opinions are entitled to great weight, that the Clevedon pebble-bed is a conglomerate of the Permian æra.

I am compelled to dissent from these views for two reasons—its position with respect to the undoubted Permian strata, and difference of lithological character. With respect to position, I have already discussed that point, and shall only add the accompanying diagram by way of illustration, constructed from the Government Geological Map (see fig.).

With respect to lithological character, the Permian rocks of the neighbourhood of Clevedon should rather be called magnesian limestone than conglomerate. They consist of a limestone, fine-grained enough to be sculptured into architectural orna-

ments, like the magnesian limestone from the north of England, used for the New Palace at Westminster; for which purpose they are occasionally found unfit, from the presence of fragments of carboniferous limestone, called by the workmen "cockles." The cement, therefore, of this quasi-conglomerate forms the greater portion of the mass; the fragmentary matter is of rare occurrence and unrolled. In the gravel-bed of Clevedon Down, fragments derived from other beds of carboniferous limestone than those on which it rests, if not from older and newer rocks, form the bulk of the mass: the tufaceous cement is small in quantity, and the fragments have been rolled.

I conclude by remarking, that if this gravel-bed shall prove, on further investigation, to belong to an era more remote than the pleistocene, it will by no means invalidate my argument respecting the southern extension of the glacial sea beyond the limits which have been assigned to it; for that extension rests on a variety of independent evidence enumerated in the commencement of this paper.

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2. *On the* Origin *of the* Soils *which cover the* Chalk *of* Kent. Part 3. By Joshua Trimmer, Esq., F.G.S.

[For Parts I. & II. see Quart. Journ. Geol. Soc. vol. vii. p. 31, and vol. viii. p. 273.]

[Plate XIII.]

We have been recently indebted to Sir Roderick Murchison* and Mr. Martin†, of Pulborough, for valuable additions to our knowledge of the superficial deposits of the South-eastern counties, within the area of the Weald, and also exterior to it, both on the North and the South Downs.

Mr. Martin‡ divides the detrital accumulations upon the Chalk into two zones, which he calls the tertiary and the cretaceous,—the former, both on the north and on the south, the most remote from the escarpments of chalk which bound the Weald.

He describes the tertiary zone as composed chiefly of rolled pebbles, derived from the eocene tertiaries. Eocene pebbles, on the contrary, enter sparingly into the composition of the cretaceous zone; which consists, he says, chiefly of whole or fractured flints, passing occasionally into beds of loam and patches of chalk rubble. In this description I concur, as to that portion of the chalk which I have examined, subject to this qualification,—that the deposits of the cretaceous zone intrude into the area of the tertiary zone, and replace it, wherever it has been much denuded.

It is to this tertiary zone, in the district between Shooter's Hill and the Medway, that I wish to draw attention in the present communication, as containing pebbles of distant origin, derived from the

* Quart. Journ. Geol. Soc. vol. vii. p. 349.

† Philosophical Magazine, 4th series, vol. ii. 1851.

‡ *Op. cit.*

north and west, with others which I refer to the south; and as forming an attenuated and modified representative of the Upper Erratic Tertiaries of the counties north of the Thames.

The cretaceous zone of North Kent will form the subject of a future communication,—"On the Mammalian Deposits of the Valley of the Thames, and their relations to the Erratic Tertiaries and the Warp-drift."

In the district which I am now describing, there are, at different heights, and of somewhat different composition, three beds of gravel, which would be all comprised in Mr. Martin's tertiary zone. I shall call them the Dartford gravel, the Shooter's Hill gravel, and the Rochester gravel. See Plate XIII., and the Table at the end of this Paper.

Dartford Gravel.—The Dartford gravel extends through Bexley and Dartford Heaths, and the Common called the Brent, as far as Greenhithe, with a breadth of about a mile, running about half a mile further up the left bank of the Darent, where it extends nearly to the church of Sutton-at-Hone.

It forms a kind of terrace, about 150 feet above the tidal level. It is higher, therefore, than the mammalian deposits of the ancient Thames. It is further, also, from the existing stream, and bounds the trough in which the ancient and more extensive river flowed (see Pl.).

This gravel has been cut through by the valley of the Darent, and by the minor inosculating valleys, which are destitute of streams. The best sections are in the gravel-pits at Wilmington, by the Orange-tree Turnpike-gate; also, in a gravel-pit on the opposite or right bank of the Darent, near the Powder Mills; in a cutting of the North Kent Railway, a little east of the Dartford Station; also, in an old pit at Sutton Place, and in some of the cuttings on the Rochester road, between Stone and Greenhithe.

In the Wilmington pit, the maximum depth of the gravel is about 15 feet; and though it is impossible to separate this deposit from that at the railway cuttings, which contains a greater variety of fragmentary rocks, I can find no pebbles here but unabraded and subangular flints, rolled eocene pebbles, and fragments of quartzose and cherty sandstone of various colours; the latter I refer to the strata below the chalk, which are exposed within the area of the Weald.

At the Powder Mill pit, the materials of which the gravel is composed are nearly the same as at Wilmington, consisting of slightly worn flints, some of them of considerable size, eocene pebbles, and the quartzose and cherty sandstone before mentioned as being probably subcretaceous.

There are some peculiarities in the mode of aggregation of the gravel at this pit worthy of notice, as indicating violent and conflicting currents during its deposition. The section is about 30 yards long; for about 7 yards at the western end, there are some tolerably regular lines of stratification. These terminate abruptly against one of those unstratified masses of loam and gravel, which in a paper on the "Pipes or Sandgalls in the Chalk of Norfolk*," I have described

* Quart. Journ. Geol. Soc. vol. i. p. 310.

as indicating the presence of a large pipe beneath them, and as known to the workmen there by the name of "core." For about 15 yards in the centre of the section, there is a bed from $1\frac{1}{2}$ to 2 feet thick of laminated loam, in the midst of a mass of loosely aggregated gravel, with little appearance of stratification. The gravel above this loam is apparently much coarser than that below; which, however, is much obscured by a talus. The eastern end of this loam, which is thickest, is curved downwards, as is another smaller seam which makes its appearance a little above and beyond it, and which terminates against another "core," composed chiefly of an unstratified mass of silty loam, but with gravel on the side having a rude vertical stratification, and with coarse gravel above it. A little to the north, there is a circular cavity in the chalk, which the workmen have followed downwards for a few feet for the sake of the fine gravel which it contains. This is composed almost wholly of small eocene pebbles, but it is evident that they have been re-arranged, from the presence of a few subangular flints and fragments of the cherty sandstone before mentioned.

In an old gravel-pit at Sutton Place the greatest depth is about 15 feet, but there are several points at which peaks of chalk rise to within 5 feet of the surface.

At the cutting near the Dartford Station, rounded eocene pebbles are the most numerous, mixed with unworn and partially abraded flints, some of them of considerable size. With them are associated in much smaller quantities other pebbles, which indicate transportation from the north and west. The most abundant of these are pebbles of white quartz, and those peculiar quartzose pebbles which form so large a portion of the gravel of the Midland Counties, formerly described by the Dean of Westminster under the name of the Warwickshire Gravel*.

It will be remembered that Dr. Buckland traced these pebbles from their source in a Triassic conglomerate, about Cannock Chase and the Upper Lickey, to the base of the Cotteswolds, and through depressions in that range to the high grounds bordering the Thames in the neighbourhood of Oxford, and thence brought by denuding action, then called by him the reflux of the diluvial wave, into the valley of the Thames, as far as Hyde Park.

With these quartzose pebbles I have found at Dartford several fragments of those sandstones which I refer to the subcretaceous rocks, one small pebble of granite, and a pebble of flinty slate, such as accompany the quartzose pebbles in the Midland counties. I have also found one flat angular piece of hornblende rock, which must be considered as doubtful, since it was not actually imbedded, and may have come from the surface and have been deposited there through the instrumentality of the London manure cart.

The gravel bed which rests on a ridge of chalk bounding the valley of the Darent on the east, varies much in the mode of aggregation through the length of the section exposed, which is about 600 yards. In some parts it consists chiefly of coarse sand, con-

* Trans. Geol. Soc. 1st Series, vol. v. p. 521.

taining irregular seams of gravel, and resembles much of the sand and gravel associated with mammalian remains at lower levels, in the ancient alluvium of the Thames. In other parts it is made up chiefly of masses of unabraded flints. In this section the gravel rests on chalk; but at a little distance to the south, there is a patch of eocene sand between them, as may be seen on the ascent from Dartford, on the Rochester road.

The surface of the chalk has been eroded into pipes of various depths, generally from 3 to 5 feet, occasionally extending to the whole depth of the chalk exposed, which is more than 30 feet, and appearing not to terminate at that depth. These pipes are filled with the gravel, not with eocene sand; and the gravel having been removed for ballast, over an area of about 80 yards by 12, these pipes are shown to be connected with furrows, which through the space exposed have a north and south direction.

The gravel is covered by a deposit of loam, containing fractured flints, and passing occasionally into gravel and chalk rubble, or reconstructed chalk. Similar deposits have been recently described by several eminent geologists, under the names of "head*," "angular flint drift†," "Sangatte drift‡," and "cretaceous and subcretaceous drift§."

Amidst this perplexing variety, I may perhaps be permitted, at any rate for the present, to use the name of "Warp-drift," under which I described it when I first drew attention to it as it exists in Norfolk‖; and in fact wherever I have examined the superficial deposits in England, Wales, and Ireland, both where the erratic tertiaries are present and where they are absent. This loamy warp-drift not only covers the gravel, but fills a set of smaller pipes and furrows in the chalk ridge on which the gravel rests, wherever that deposit has been removed by denuding action. We have therefore, in this part of Kent, three sets of these pipes and furrows; viz. those filled with eocene sand and green-coated flints; those filled with the ferruginous flint-gravel of Dartford; and those filled with warp-drift and white unabraded and fractured flints¶. The last are by far the most numerous. Along the course of the railway, between this cutting and Greenhithe, the surface of the chalk exposed in the cuttings is generally lower than at this spot, and is covered by warp-drift under all its varying forms. It frequently exhibits alternation of deposit. At the base there is often a collection of angular flints. Above this, a foot or two of loam, resembling a deposit from tranquil water. This occurs where there are hollows in the chalk; over this again there is a mixture of loam with white flints, or patches of ferruginous gravel, or both; the gravel resembling that of the neighbouring high

* Quart. Journ. Geol. Soc. vol. vii. p. 121.

† *Ibid.* p. 349.

‡ *Ibid.* p. 274.

§ Phil. Mag. *l. c.*

‖ Journ. R. Ag. Soc. vol. vii. p. 465, vol. xii. pp. 475, 489. Quart. Journ. Geol. Soc. vol. vii. p. 24; Par. 15, pp. 29, 32, 35, 36, 202; also in a paper withdrawn for separate publication and not yet published, vol. viii. p. 273.

¶ Proc. Geol. Soc. vol. iv. pp. 6, 482; Quart. Journ. Geol. Soc. vol. vii. p. 23; vol. viii. pp. 244, 276; and unpublished paper, vol. vii. p. 273.

grounds, which I have above described under the name of Dartford gravel.

In the cuttings on the old Rochester road, between Greenhithe and Gravesend, there are only slight remains of the Dartford gravel, either as filling pipes in the chalk, or as forming a thin film between the chalk and the warp-drift.

Between Gravesend and Gadshill there is nothing to be seen in the road-sections except a rather deep warp-drift of loam and angular flints, resting in some places on the chalk, in others on the Thanet Sand. But on the summit of Gadshill, there are again slight traces of the ferruginous gravel. At the eastern base of that hill, we come on the warp-drift again; and between the solid and the reconstructed chalk, I found a few eocene pebbles and fragments of ferruginous sandstone, the reconstructed chalk being covered with several feet of loam with flints. This passes into the same kind of deposit, of greater depth, which, at lower levels, within the valley of the Medway, covers beds of brick-earth, graduating horizontally into gravel and masses of chalk rubble. These will be described in a future paper, in which I shall show that they rest on deposits containing land and freshwater shells.

In tracing the Dartford gravel westwards, eocene pebbles are found to increase in quantity, between the Darent and the Cray; west of the Cray, they prevail almost to the exclusion of other materials. The outcrop of one of the pebble beds of that period ranges near Bexley Heath, where the superficial deposits consist wholly of those pebbles, re-arranged in a base of yellow sand and loam, of a different colour from that of the original matrix.

Shooter's Hill Gravel.—On the summit of Shooter's Hill, and at an elevation therefore of nearly 446 feet, there is a bed of gravel in which partially worn flints again make their appearance (see Plate XIII.). Many of the rolled pebbles associated with them have been derived probably from some eocene bed; but there are others which appear to have been reduced to that state during the formation of this gravel, because flints occur in it in different stages of attrition, from the least to the most rolled.

Rochester Gravel.—The Rochester gravel occurs near Ring's Farm, on the right bank of the Medway, about two miles above Rochester, at an elevation which, I believe, is somewhat less than that of the Dartford gravel.

The surface of the fields under which it occurs is very thickly strewn with sharply fractured flints. A gravel-pit which was open in 1852, but which is now levelled and ploughed over, showed the gravel to be about 15 feet deep. The upper part consisted of a ferruginous clayey loam with angular flints, very similar to that which covers the summits of the higher chalk hills, and bears the provincial name of "cledge." It passes occasionally into masses of angular flint-gravel in a clayey matrix. In the lower portion of the deposit white flints prevailed, accompanied by a few fragments of chalk, and some unabraded fragments of concretionary chert, containing or passing into flint, and derived, I believe, from part of the green-

sand formation. The gravel also contained some small waterworn boulders of a dark ferruginous sandstone, some rolled eocene pebbles, and fragments of a conglomerate, in which those pebbles are cemented by a base of ferruginous sandstone. I could find no other detritus foreign to the chalk.

General conclusions.—In former communications* I have divided the erratic tertiaries, commonly called northern drift and drift, into Lower Erratics, consisting of Till† or Boulder Clay, and Upper Erratics‡ composed of rolled gravel with erratic blocks. I endeavoured also to prove, by means of extracts from the narratives of the Polar Expeditions§, that the boulder clay was the littoral deposit of an arctic sea, which gradually crept, with the subsidence of the land, to certain elevations in the interior, at which it ceased to be deposited, and was replaced by the rolled gravel of the upper erratics, which covers it at lower levels. I also endeavoured to prove, by the same means, that these upper erratics were the deposits of a more open sea, like that of Davis's Straits, though they might be in part the result of a less rigorous climate during their formation.

I also adduced proofs of the existence of a former terrestrial surface in the Forest of Cromer, buried beneath the mass of the erratic tertiaries ‖; and I concluded that the gradual advance of a frozen sea over subsiding land, and the gradual retreat of the arctic climate northwards during re-elevation,—the subsidence and re-elevation commencing in each case from the north,—would explain all the peculiarities, whether of composition or distribution, of the erratic tertiaries north of the Thames. I believe that they will also explain the anomalies of the erratic deposits of Kent, which I have just described.

The boulder clay does not extend across the valley of the Thames, though it comes down to its northern edge (see Pl. XIII.). It appears to have been cut off by a ridge of eocene tertiaries, of which the Highgate range and Shooter's Hill may be considered the remains. This ridge appears not to have been submerged until the causes which produced the boulder clay had ceased; but it was ultimately submerged, and the gravel of Shooter's Hill must be considered as an outlier of the upper erratics which overlapped the lower erratics on a ridge of eocene tertiaries, since in great part removed, which then occupied the site of the Thames Valley. See Diagram, Pl. XIII.

North of that river, the valleys in general appear to have been formed before the submergence of the erratic period¶,—to have been filled with the erratic deposits, and re-excavated during the period of emergence. The valley of the Thames, on the contrary, appears to have been originally excavated in the London clay during the period

* *Loc. cit.*

† Journ. R. Ag. Soc. vol. vii. pp. 461–464. Quart. Journ. Geol. Soc. vol. vii. p. 21, par. 3, 4, 5.

‡ *Ibid.* par. 8.

§ Unpublished paper on evidence of Extreme Arctic Climate during the formation of the Erratic Tertiaries: *Loc. cit.* And Quart. Journ. Geol. Soc. vol. vii. par. 5 and 7.

‖ Vol. vii. p. 20, par. 1, 2, 3.

¶ Quart. Journ. Geol. Soc. vol. vii. p. 21, par. 6.

of re-elevation. If these views are correct, we may look for similar outliers of the upper erratics at high levels, where a surface of the upper eocene beds remains unbroken; but we cannot expect them where the lower beds or the chalk have been exposed by the denuding process. Beds of gravel at low levels will consist of the materials of the upper erratics re-arranged.

The Shooter's Hill gravel having been thus formed towards the close of the period of submergence, the absence of pebbles, indicating transportation from the north and west, may be thus explained: the Warwickshire gravel had not then passed the Cotswold range; or, if it had, it was only spreading itself over the high grounds bordering the Cherwell and Thames near Oxford.

The Dartford gravel, on the other hand, at a lower level, contains those pebbles, because it was formed at a later period, during the process of re-elevation, when the Warwickshire gravel had been brought into the trough of the Thames by the denuding action which formed that trough, and which left outliers of erratic tertiaries on the summits of Bagley Wood, Cumnor Hurst, and other neighbouring hills, as described by Dr. Buckland*.

At a still more recent portion of the re-elevation period, these pebbles were removed from the Dartford gravel to lower levels, and formed part of the gravel of the ancient river, associated with mammalian remains at Erith, where I have found them, and at Brentford, where they have been found by Mr. Morris †. The absence of the pebbles of Lickey quartz-rock and other fragments of northern origin from the Wilmington pits and from the Rochester gravel, within the valleys of the Darent and Medway respectively, and the presence in both those deposits of pebbles which appear to have been derived from strata below the chalk which are exposed within the Wealden area, indicate transportation outwards about the middle of the period of re-elevation through the gorges now occupied by those rivers. If the denudation of the Weald and the separation of the eocene tertiaries of the London and Hampshire districts were in progress, as I believe they were, during the latter portion of the period of submergence, and while the Shooter's Hill gravel was in the course of formation, it will explain why that gravel consists only of materials derived from the chalk and eocene tertiaries, and why northern detritus, so abundant in Norfolk, Suffolk, and Essex, is absent, as well as the Lickey quartzose pebbles. The advance of these northern erratics was repelled by movements of disturbance, along an east and west line, which gave the currents an easterly direction.

The mammalian deposits of the valley of the Thames must be referred to a subsequent period of quiescence, and may be considered contemporaneous with the ancient beach at Brighton beneath the bone-bed; the materials of that beach, and of the old alluvial deposits of the Thames, which had previously been transported, having been re-arranged during that period of quiescence.

* Trans. Geol. Soc. 1st Series, vol. v. p. 521.

† Quart. Journ. Geol. Soc. vol. vi. p. 202.

I cannot, with Mr. Austen*, place the Brighton old beach on the parallel of the Crag; for this reason, that it contains pebbles and boulders of granite, and other crystalline rocks of northern origin, which are not found in the Crag, and which do not make their appearance in any deposit till the commencement of the Boulder clay or Lower erratics.

The granitic fragments of Brighton were probably transported during the latter portion of the Boulder-clay period.

In illustration of these views, I refer to the accompanying maps (in Plate XIII.) of the changes which would take place in the physical geography of this north-western extremity of Europe, at different stages of the process of depression and re-elevation, during the pleistocene epoch.

No. I. represents the first elephantine or stationary period,—the period of the Forest of Cromer and Happisburgh, which is rooted in the mammalian crag,—when England and Scotland were united to the Continent.

I have represented Ireland and England as united also; but from the general dearth of elephantine remains in Ireland, this may be considered as doubtful.

No. II. represents the close of the period of boulder-clay, when the whole of Great Britain and Ireland was submerged, except the summits of mountains exceeding 1500 feet in height, and except in England the counties south of the Thames, or rather of the present site of the Thames.

At this period we may suppose England still united to the Continent in the direction of Normandy and Cornwall, and a gulf to have occupied part of the north of France, and the eastern part of the present site of the English Channel; and into this gulf the granitic fragments may have been transported, which were afterwards rearranged in the ancient beach of Brighton.

No. III. represents the latter portion of the period of Upper Erratics. The southern counties were now submerged, and the formation of the anticlinal of the Weald in progress.

We may suppose Scotland, Ireland, and the north of England to have been re-elevated at this time in the direction of Scandinavia and the north of Germany, and thus re-united to the Continent.

This was the period of the immigration of the Reindeer and Megaceros; and the tracts represented as reconverted into land are those in which the remains of the latter are most abundant.

At this period the deposits of the Clyde and Forth would be laid dry; and this early elevation will explain the more arctic character of their shells as compared with those of the valley of the Nar,—a difference which has been noticed by palæontologists as greater than can be ascribed to difference of latitude alone.

In No. IV. England is represented as completely re-elevated and again united to the Continent on the south-east, but separated on the north-east. The Thames was then a river of greater volume, and extending further eastward, than the present stream; for its ancient

* Quart. Journ. Geol. Soc. vol. vii. p. 136, tabular view.

alluvium contains only land and freshwater shells at points much nearer to the sea than those at which estuary conditions prevail at present. This fact, and the conclusion to be drawn from it, were first pointed out by Mr. Austen, though he refers it to the commencement instead of the close of the pleistocene epoch. He also insisted on the evidence, afforded by this ancient alluvium of the Thames, of the land having had a greater elevation at that period. Without adopting his views on this point to their full extent, I am satisfied that there has been some amount of depression, since this old alluvium of the Thames was formed; because those land and freshwater shells which I sent to the Museum in 1841, from Faversham, were collected from a bed which extended below the level of the sea.

I have represented a gulf as running up the English Channel from the west as far as Dover, and another as extending between Wales and Ireland, as far as Wexford. To this period I refer the ancient beach at Brighton, and the marls and gravels at Wexford, which contain the southern forms described by the President in the Memoirs of the Geological Survey of Great Britain. Those deposits were first described by Mr. Griffith, in the Journal of the Geological Society of Dublin*, as occupying an area of about 20 miles by 5. They were also described to me by Captain Charles Le Hunte, on whose authority I first drew Mr. Griffith's attention to them, as confined to the valley of the Slaney. This was in 1835, and he then spoke of having seen, in the houses of the peasantry, shells said to have been derived from these beds, respecting which he thought there must have been some mistake, in consequence of their resemblance to tropical forms.

It was at this period that the Elephants and other now extinct pachyderms returned, and became intermingled with the Megaceros and Reindeer, which had arrived from the north during an earlier portion of the period of re-elevation. To this second elephantine period I refer the few remains of the Elephant which have been discovered in Ireland.

Dr. Scouler says (Journal of Geol. Soc. Dublin, vol. i. p. 202), that in the only authentic instance on record of their occurrence in that country, they were in a position indicating a date as modern as those of the Megaceros. They were found resting on a bed of fern leaves.

At this period, the present physical features of the Weald and North Downs were completely established; and I shall show in a future communication, that those deposits which Sir Roderick Murchison calls angular drift, which Mr. Martin calls cretaceous and subcretaceous drift, and which I call warp-drift, were subsequently poured into the valleys of the Thames and Medway; and that they cover mammalian deposits containing land and freshwater shells.

I offer no opinion respecting the nature of the agencies by which this angular drift or warp-drift was formed; nor whether they were connected with the final separation of England from the Continent, and the final disappearance of the great pachyderms, which are not

* Vol. i. part 3. p. 152.

Tabular view of the Pleistocene Deposits of Norfolk, the Valley of the Thames, and the South-eastern Coast, from the period of the Mammalian Crag to the disappearance of the Elephantine and other extinct Pachyderms.

NORFOLK.	THAMES AND ITS TRIBUTARIES.	SOUTH-EASTERN COAST.
	Modern or Alluvial Period.	
Marshes of the Yare, an estuary in Saxon times (Taylor). Marshes of the Wash.	Marshes of Plumstead, Dartford, Gravesend, and elsewhere in Kent and Essex.	Lewes and Pevensey Levels, formed antecedently to the Roman Invasion (Mantell). Bones of Man, Deer, Cetacea.
	Period of the Warp-drift.	
Warp-drift (Trimmer, 1846). Thin and thick beds of loam with angular flints, heaps of chalk rubble, heaps of angular flints.	Upper brick-earth of Brentford, without fossils (W. K. Trimmer, 1813). Upper brick-earth of Ilford, Erith, Rochester (Morris, Trimmer).	Elephant bed (Mantell). Head (Austen). Angular flint-drift (Murchison). Cretaceous and subcretaceous drift (Martin). Sangatte drift (Prestwich). Thin and thick beds of loam with angular flints, heaps of chalk rubble, heaps of angular flints.
	Second Terrestrial or Second Elephantine Period.	
Nar clay, — Marine (Rose). Gaytonthorpe, — Freshwater (Trimmer).	Ancient wide-spread alluvia of the Thames and its tributaries. Remains of Elephants, Rhinoceros, Hippopotamus, Carnivora; land and freshwater Shells; pebbles of Lickey quartz-rock and of granite (W. K. Trimmer, Morris, Trimmer).	Ancient beach beneath elephant bed at Brighton. Marine shells; remains of Elephant; pebbles, and rounded blocks of granite, porphyry, slate, and palæozoic limestone (Mantell, Murchison).
	Period of Re-elevation.	
Valley deposits at various heights: materials of erratic tertiaries re-arranged.	Gravel of Rochester, fragments of chert, eocene pebbles, rounded boulders of ferruginous sandstone. The chert indicates transport outwards from the chalk escarpment. Gravel of Hyde Park. Dartford gravel. Pebbles of Lickey quartz-rock, granite, and flinty slate.	Subangular flint gravel of Hants and Dorset at low and intermediate levels.
	Period of Subsidence.	
*Upper erratic tertiaries, sand and gravel, with erratic blocks and pebbles. The small detritus rolled; only the *large* blocks scratched. Lower erratic tertiaries, till, or boulder clay; first appearance of northern erratic pebbles and boulders; *small* detritus scratched. Marine bed, Runton.	Shooter's Hill gravel, rolled and subangular flints; no organic remains.	Subangular flint gravel of Hants and Dorset at high levels.
	First Terrestrial, or First Elephantine Period.	
Freshwater beds, Runton and Mundesley. Pine forest of Cromer and Mundesley, rooted on the mammalian crag of Cromer. This crag is perhaps somewhat more recent than that of Bramerton, which contains remains of the Mastodon.	Eocene tertiaries and chalk of these two districts not submerged till late in the period of the upper erratics. The fracture and denudation of the chalk and tertiaries in progress during the period of submergence and re-elevation, and completed before the period of the warp-drift.	

* Marine shells are not so abundant in either upper or lower erratics in Norfolk, as in Lancashire, Cheshire, and North and South Wales.

found in any subsequent deposit. I agree with Mr. Prestwich*, that little more can be affirmed of them at present, than that they were violent, transient, and suddenly arrested. To this I shall add proofs, that the action was intermittent, and that while great swishes of water came off the land, forming these angular deposits, river action continued, causing them to alternate with more than one deposit of mammalian remains and river shells, in those deep beds of brick-earth which occur near the outskirts of the ancient alluvium of the Thames, at Erith, Ilford, &c.

At page 295 is a synoptic table of the different deposits of the pleistocene æra in Norfolk, the valley of the Thames, and on the south-eastern coast, arranged chronologically according to these views. Plate XIII. exhibits a diagram-section illustrating the amount of denudation of the Erratic Tertiaries, the Eocene Tertiaries, the Chalk, and the subjacent rocks of the area of the Weald, which I consider to have taken place during the latter part of the period of pleistocene submergence, and during the period of re-elevation, up to the stationary period which preceded the operations of the warp-drift.

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3. *On the* Geological *and* Glacial Phænomena *of the* Coasts *of* Davis' Strait *and* Baffin's Bay†. By P. C. Sutherland, M.D., Late Surgeon in the Arctic Expeditions.

[Communicated by Prof. A. C. Ramsay, F.G.S.]

From Cape Farewell to Cape Atholl.—The Danish settlers in Greenland have pretty accurately laid down the geological character of the eastern coast of Davis' Straits from Cape Farewell, about lat. 60°, to Cape Shackleton, about lat. 74°‡. Beyond this latitude and down the west side of Davis' Straits, the coast is almost unknown, from the difficulty experienced in approaching the land by the Whaling and Discovery Ships, the only ships that ever attempt to reach it.

Commencing at Cape Farewell (Sketch No. 1), we find the crystalline rocks§ (granite, gneiss, &c.) forming a rugged and pinnacled coast, intersected by fiords of great length, in which the tide is

* Quart. Journ. Geol. Soc. vol. vii. p. 276.

† The author has presented to the Society a series of original sketches (referred to in the memoir) illustrative of the geological and glacial conditions of different parts of the coasts described in the paper. These are accompanied also with a chart on which the geological indications are laid down as carefully as the author's observations, often necessarily made at some distance from the shore, permitted. Other sketches of portions of the coasts of West Greenland, Cockburn Land, North Devon, &c., are published in the author's Journal of Capt. Penny's Voyage, 1852. Cape York and the eastern coast of Smith's Sound are illustrated by lithographs in Capt. Inglefield's 'Summer Search for Sir J. Franklin,' 1853.

‡ See Rink's Geology of West Greenland, 1852, Trans. Roy. Soc. Denmark.

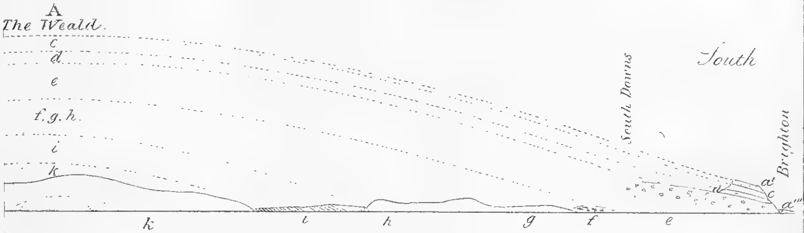
§ Copper, tin, lead, and silver ores have been discovered in the vicinity of Julianes-Haab, about a degree north-west of Cape Farewell; and at Upernivik, about lat. 71°, graphite of tolerable purity occurs in abundance.

lk, and the subjacent rocks,

the Stationary Period,

ift.

descended during the Period of Re-elevation to the Greensand, in the Dartford gravel and the Rochester gravel.



- c. London Clay.
- d. Lowest Eocene Tertiaries.
- e. Chalk.
- f. Upper Greensand.
- g. Gault.
- h. Lower Greensand.
- i. Weald Clay.
- k. Hastings Sand.

No. IV.

STATIONARY PERIOD.

The shaded parts represent _ Land, and the blank spaces Water.

Second Elephantine Period.

(South of England re-elevated)

Ferd & West, imp.

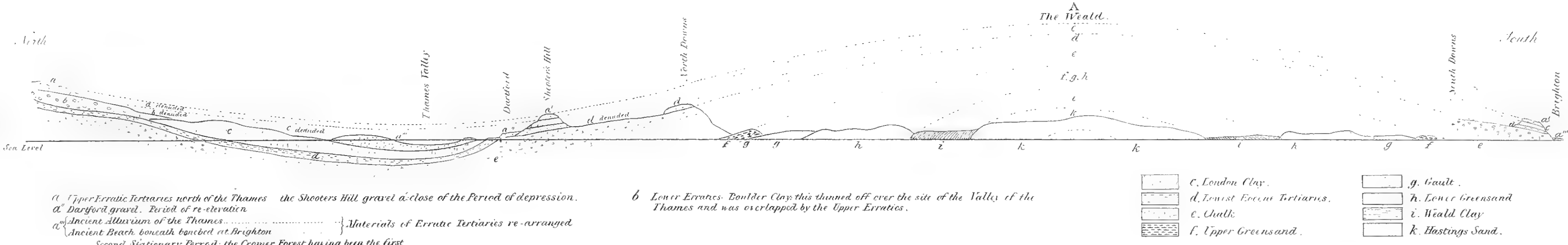
A DIAGRAM SECTION

across

the Valley of the Thames, to the Sussex Coast;
illustrative of the denudation of the Erratic Tertiaries, the Eocene Tertiaries, the Chalk, and the subjacent rocks,
from the
close of the Pleistocene Period of Depression, through the Period of Reelevation, up to the Stationary Period,
or
Second Elephantine Period,
immediately preceding the formation of the Warp-drift.

NOTE.

The wreck of the Eocene Tertiaries and the Chalk removed from over the anticlinal at A, formed the Shooter's Hill Gravel. As the denuding action descended during the Period of Re-elevation to the Greensand, fragments of sandstone and chert came through the gorges of the Darent and the Medway, and were mixed with the Chalk and Tertiary detritus in the Dartford gravel and the Rochester gravel.



a. Upper Erratic Tertiaries north of the Thames — the Shooters Hill gravel a': close of the Period of depression.
a''. Dartford gravel. Period of re-elevation.
a''' {Ancient Alluvium of the Thames ......; Ancient Beach beneath bonebed at Brighton} Materials of Erratic Tertiaries re-arranged.
Second Stationary Period: the Cromer Forest having been the first.

b. Lower Erratics: Boulder Clay; this thinned off over the site of the Valley of the Thames and was overlapped by the Upper Erratics.

Sketch Maps illustrating the Changes in the Distribution of Land and Sea during the Pleistocene Epoch.

N° I.
COMMENCEMENT OF BOULDER CLAY.

First Elephantine Period.
(Cromer Forest)

N° II.
CLOSE OF BOULDER CLAY.

Period of Submergence.

N° III.
CLOSE OF UPPER ERRATICS.

Immigration of Megaceros and Reindeer.
(North of England re-elevated.)

N° IV.
STATIONARY PERIOD.

Second Elephantine Period.
(South of England re-elevated.)

The shaded parts represent — Land, and the blank spaces Water.

Gc. Achilles, lith.

Ford & West, imp.

generally very rapid, and the water is of considerable depth. The coast indeed appears as if composed of a cluster of islands varying much in size and lying in front of the great glacial plateau constituting the continent of Greenland.

Disco Island, Black Hook, &c.—Proceeding northward we find Disco Island, on the 70th parallel of latitude, to be chiefly composed of trap-rock *. Viewing this island from a distance of ten miles, it presents a succession of steps, and appears to be made up of a number of truncated cones, planted so closely together that the bases of all meet; some of them, at the level of the sea, bounding long and winding valleys, and others at every intermediate elevation, until the top itself is reached at a height of from 2000 to 5000 feet. At its southern extremity hypogene rocks (granite, &c.) occur, from the sea-level to an elevation of about 100 feet, and passing beneath the trappean formation. In South-east or Disco Bay several clusters of islands are observed, all of which appear to be composed of the same crystalline rocks. On the S.E. and N.E. shores of Disco Island, the N. shore of the Waigat Strait, Hare Island, the S. shore of Omenak Fiord, Upernivik Naes (North-east Bay), and in the neighbourhood of the Black Hook, on the 72nd parallel of latitude, coal (lignite) has been found to a considerable extent and of rather tolerable quality. The specific gravity of the coal is 1·3848, and the following analysis of its proximate ingredients, made by Dr. Fyfe, Professor of Chemistry, King's College, Aberdeen, upon a specimen obtained from the same source as that now in the Museum of this Society, enables us to judge of its value and purity :—

Volatile matter		50·6
Coke, consisting of		
Ash	9·84	
Fixed carbon	39·56	
		49·40
		100·00

I have not myself visited the beds of this mineral, but from the recent elaborate reseaches of Dr. H. Rink, the enterprising Danish traveller, it appears that sandstone is associated with this coal.

At Cape Cranstoune, situate on the north side of North-east Bay (Omenak Fiord), and immediately adjacent to the above two localities, the trap-rocks again occur, and thence extend northward, apparently in one unbroken series, as far as Proven, in lat. 72° 20′. Northward of this to Cape York, lat. 76°, with one or two slight exceptions, in lat. 73° 20′ and lat. 74°, the numerous islands and every part of the coast that protrudes from beneath the glacier are composed of gneiss and granite.

Capes York and Atholl.—At Cape York, lat. 76° (Sketch No. 2, fig., p. 301), and on to Cape Atholl, thirty to forty miles further north,

* See Rink, *op. cit.*

although differing in outline, owing to the glacial accumulation, from Disco Island and other well-known parts of the coast to the southward, the rocks can be referred with certainty to the same trappean formation. Specimens of greenstone-porphyry were taken from the cliffs at Petowak, near Cape Atholl.

Wolstenholme Sound to Cape Hatherton.—Northward of Cape Atholl we find, in the entrance of Wolstenholme Sound, a flat island (Saunders Island), which from its distinctly *stratified* appearance suggests the commencement of a different series of rocks. And eastward of the same cape, on the south shore of this Sound (Sketch No. 3, *a* and *b*), the strata are seen cropping out with a dip to the south-west. This is at variance with what we observe in Saunders Island, about twelve miles N.N.W., for there the strata are perfectly horizontal. At North Omenak (Sketch No. 3, *d*) a sandstone, or slaty quartzose grit, with a dip of about 15° to W.S.W., occurs interstratified with greenstone-porphyry; and it is very probable that Mount Dundas, a tabular hill with a talus (Sketch No. 3, *c*), is also composed of igneous rock. At the top of Wolstenholme Sound, in the same bluff, the strata, dipping about south-west, vary in their inclination from 10° to 25° or 30°. In Granville Bay (Sketch No. 5), about twenty miles farther north, the strata are at one place (at *a* in the Sketch) but little out of the horizontal, and at *b* the dip is about 45° to the north-west, and at *c* we have strata somewhat curved. In the entrance of Granville Bay several small islands occur (Sketch No. 5, *d*), which are probably formed of trap-rock. In Booth Sound, lat. 77°, near Cape Parry (Sketch No. 6, *a*), there is a very remarkable bell-shaped rock (Fitzclarence Rock), of a dark colour and rising in an isolated form to a height of probably 500 or 600 feet, as if from out of a comparatively level spit of ground: this also appears to consist of similar rock. From Cape Parry (lat. 77° 5′) north-eastwardly to Bardin Bay (lat. 77° 20′), in the south shore of Whale Sound (Sketch No. 6, *c*), the strata incline a little to the S.W., and in many places they are somewhat curved. Still farther to the north-east they have a general dip of 30° to S.W., and they are intersected by irregular dark-coloured dikes of igneous rocks. One of these dikes (Sketch No. 6, *b*) rises in the form of a rough peak above the outline of the strata. In the entrance of Bardin Bay, the ship, drawing ten to twelve feet of water, struck upon a rock, which from the depth of the water (fifty to sixty fathoms) within a couple of hundred yards, may be a second protrusion of the same dike above the stratified rocks. Specimens of quartzose grit were obtained from the low point (Sketch No. 6, *d*) on the north-east side of Bardin Bay, and were taken from strata inclining W.S.W. at a general angle of 15°, but a little curved. In them we recognize the same sandstone as that of North Omenak, about sixty miles to the southward. A specimen of syenitic porphyry was taken from the shoulder of the hill in the vicinity of the dike above-mentioned (Sketch No. 6, *b*). In other parts of Whale Sound (in Northumberland, Herbert, and Milne Islands) the strata are perfectly horizontal; and at Cape Saumarez (Sketch No. 7, *a*), on the same coast, but thirty miles further north, the same strata can be

traced from one cliff to another in conformable and horizontal lines over many miles. At Cape Alexander (Sketch No. 8), the eastern boundary of the entrance of Sir Thomas Smith's Sound, in lat. 78° 15′, we again find the strata somewhat curved; but about seven miles farther north (a few miles south of Cape Hatherton), they are so regularly and horizontally piled one on another, that from their peculiar appearance they have received the name of the Crystal Palace Cliffs (see Sketch No. 8). A small island (Sketch No. 8, *a*), lying in front of a glacier two miles southward of Cape Alexander, appears to be composed of a dark rough-grained sandstone, similar to that found in Whale Sound (see Sketch No. 6, *d*). The strata are somewhat indistinct from the large disintegrated fragments that occupy the surface; they appear, however, to incline to the westward at an angle of ten or fifteen degrees.

West Coast of Baffin's Bay. Smith's Sound.—The west shore of Smith's Sound, from Victoria Head, beyond the 79th degree of latitude, to Cape Isabella near the 78th, as well as the coast leading southwardly to Jones' Sound, is so inapproachable from the drifting pack-ice in the season for navigation, that I fear we shall not soon have specimens of the rocks by which the character of so large a portion of the coast can be determined; and it is, moreover, everywhere so covered by the glacier, that the outlines of mere protrusions of the land, taken at a distance of ten to twenty miles, scarcely afford the materials for correct results. From its greater height in many parts than the adjacent, opposite shore, and also from its rugged, in some cases even pinnacled, contour, thus resembling the coast at Cape Farewell, it probably consists for the most part of crystalline rocks.

Jones' Sound, and North Devon.—Similar appearances obtain (with some local exceptions) along the north* and south shore of Jones' Sound, the Cobourg and neighbouring islands†, and the eastern coast of North Devon.

Lancaster Sound to Cumberland Sound.—On the opposite shore of Lancaster Sound, at Cape Walter Bathurst, the crystalline rocks are again recognized, and from this point they occupy the whole coast southward to Cumberland Strait, and probably considerably beyond it. To this, however, I believe there is one exception at Cape Durban, on the 67th parallel, where coal has been found by the whalers; and also at Kingaite, two degrees to the south-west of Durban, where, from the appearance of the land as viewed from a distance, trap may be said to occur on both sides of that inlet. Graphite is found abundant and pure in several islands situate on the 65th parallel of latitude in Cumberland Straits‡, on the west side of Davis' Straits.

Silurian District of the Georgian Islands, &c.—The above-mentioned extensive development of crystalline rocks is flanked to the

* See Sketch (No. 9) of the coast from Cape Clarence to Pickthorne Bay.

† See Sketch No. 10.

‡ Cumberland Straits of Baffin, its original discover at the end of the sixteenth century; Hogarth Sound of Capt. Penny, who rediscovered it in 1839; and Northumberland Inlet of Capt. Wareham in 1841.

westward by an equally, if not much more, extensive tract of Silurian rocks, the limits of which as yet we have been unable to ascertain. The chief, indeed, it may be said, the only navigable channel through which this Silurian district has yet been reached is Lancaster Sound; it is probable, however, we may find it continuous to the westward with the American series of the same rocks. Through the labours of Prof. Jameson and M. König, thirty years ago *, and of Mr. Salter only very recently †, some of the numerous Silurian fossils peculiar to North Somerset, North Devon, and the North Georgian Islands, have been described from the fragmentary specimens brought home by the ships engaged in the discovery of these places during the last thirty years ‡.

Drift Deposits.—On Cornwallis and Beechey Islands in Barrow Straits, west of Lancaster Sound, deposits containing existing arctic sea-shells, occur at every elevation up to nearly 1000 feet,—the greatest height attained by any part of that district. On the undulating slopes and along the raised beaches of this Silurian district of the North Georgian Islands, &c., occur travelled materials, such as fragments of anthracite, greenstone, quartz, serpentine, gneiss, and granite, but all of such small size, that their mode of conveyance to their present position is clearly referable to the action of *coast-ice* (previous to the elevation of the land), such as at the present day occupies the comparatively shallow seas in the inlets and channels of that district.

On the Greenland side of Davis' Strait, on the contrary, we find immense travelled boulders of gneiss and granite resting on the islands and the coast, which have been brought there at former periods by floating icebergs, previous to the elevation of the coast above the sea-line. The probable causes of these differences of ice-action on these two opposite coasts are explained in the subsequent observations.

It may be noticed also, that, from the observations of Dr. Pingol and Capt. Graah, the west coast of Greenland presents evidence of its now undergoing the process of gradual submersion.

Glacial conditions.—At Cape Farewell the fiords run so far into the interior, that none of the icebergs escaping into them from the great inland glacier ever reach Davis' Straits, and if the navigator meets with icebergs in the neighbourhood of this promontory, they must have drifted to it from other sources. As we advance northward along the coast of West Greenland, and thus diminish the annual mean temperature both of the sea and of the atmosphere, we find the glacier approaches nearer and nearer the coast-line, until in Melville Bay, lat. 75°, it presents to the sea one continuous wall of ice, unbroken by land, for a space of probably seventy or eighty miles.

* Appendix to Capt. Penny's Voyages.

† Appendix to Sutherland's Journal of Capt. Penny's Voyage, 1852, 2 vols. 8vo. See also Mr. Salter's Paper, *infra*, p. 312.

‡ The Rev. Mr. Longmuir, of Aberdeen, found numerous specimens of the genus *Rhynconella* in the ballast of the "Prince Albert," a ship recently returned from Batty Bay, Prince Regent's Inlet, on the eastern shore of North Somerset.

Fig. (Sketch No. 2).—*Cliff-view, Cape York.* Lat. 76°. Length about 10 miles.

To the southward of Melville Bay, there are numerous outlets for the ice in the coast, and they vary in breadth from two or three up to fifteen or twenty miles. To have a correct idea of the glacier accumulation in Greenland, we must imagine a continent of ice flanked on its seaward side by a number of islands, and in every other direction lost to vision in one continuous and boundless plain. Through the spaces between these apparent islands, the enormous glacial accumulations slowly seek their passage to the sea (see fig.), and send off an annual tribute of icebergs to encumber, to cool, and to dilute the waters of the adjoining ocean.

The average height or depth of the ice at its free edge in these intervals, or valleys, between the projecting points of coast is 1200 or 1500 feet, of which about one-eighth, or 150 feet, will be above water. In some of the valleys, however, the depth is upwards of 2400 feet. This may be considered to be satisfactorily ascertained, for the Esquimaux around South-east Bay, lat. 68°, while pursuing halibut-fishing during the winter months, require lines of three hundred fathoms to reach the bottom at the foot of the glacier near Claushaven. In South-east (Disco) Bay, and also in North-east Bay (Omenak Fiord), we meet with the icebergs that draw the greatest depth of water, but those of the greatest cubic contents occur in Melville Bay and in several smaller bays to the southward of it. At Cape York, lat. 76°, although the glacier there is the northward continuation of the glacier in Melville Bay, its protrusions into the sea (Sketch No. 2, *a*, see fig.) never exceed 50 to 60 feet above the sea-level; and in some places it does not enter the sea in a continuous mass, but having descended over the brow of the cliff, it breaks off and slips down into the sea over the rocks, scratching and scoring them in a very marked manner. This

is very well seen in the localities represented in the accompanying figure at *b* and *c* (foregoing page), where the free edge of the ice is upwards of 20 feet thick, and at least 100 feet above the sea-level; the inclination of the abraded part of the coast being about 43°. But it is much better seen on the west side of Baffin's Bay, at Cape Fitzroy, on the south side of Jones' Sound, and at Cape Bowen, Pond's Bay, where the free edge of the ice is at least 50 feet thick, and about 200 feet above the sea-level. Although many hundred miles of coast intersected by glaciers were examined in the late voyage of the "Isabel," under the command of Capt. Inglefield, R.N., these cited localities were the only places, with one or two very trifling exceptions, where this interesting phænomenon of powerful abrading action was observed. I believe it can be so far accounted for by the steepness of the inclination, but chiefly by the greater friability (diminished plasticity) of the ice from the diminished temperature.

One cannot easily determine why the icebergs that come from the glaciers at, and to the northward of, Cape York and on the west side of Davis' Straits, are of less dimensions generally than elsewhere. At Cape York, where we have a new formation of rocks (trappean) commencing, and further northward in the same coast, it is probably owing to the comparative shallowness of the valleys and to a diminished supply of snow from the greater intensity of the cold. On the west coast, from Victoria Head to Jones' Sound, although the land has almost a perfect icy casing, the icebergs that are sent off are by no means large, and this, as in the other case, may arise from the decrease of evaporation with the decrease of temperature. Again, from Jones' Sound southward, there cannot be such extensive accumulations of ice as on the opposite and more northern shore of Greenland, although the rocks in both cases are of the same character generally, for the reason, I believe, that the vapour-bearing stratum of air coming from the southward, over an extensive tract of land, contributes but scantily to the growth of the glacier on the former as compared with the latter, which is liberally supplied by the vapour-charged currents going northerly from the North Atlantic and Davis' Straits. But it is still more difficult to account for the entire absence of glaciers on the *Silurian rocks* westward of Lancaster Sound. Why the snow and rain falling on the land around Barrow Straits and its tributary inlets and bays should all escape into the sea in running streams of water every year during the two short months and a half of June, July, and August, while that falling on the coasts of Davis' Straits makes its escape as hard, but yielding ice, after a lapse of many ages, is a question worthy the attention of the student of physical phænomena.

The annual mean temperature in the creeks and inlets of Barrow Straits is several degrees lower than that in corresponding latitudes on the shores of Davis' Straits; and even at Wolstenholme Sound, nearly two degrees higher latitude, the annual mean temperature is nearly three degrees higher than at Melville Island. This, however, will not throw light upon our difficulty. The ranges of temperature will probably prove more useful. A few degrees above

the freezing-point of water would settle the question. We know that the sea exerts a wonderful influence in rendering the climate temperate, as well as in reducing the ranges of temperature. Upon this theory, so clearly illustrated in Sir Charles Lyell's 'Principles of Geology *,' the summer in the neighbourhood of Barrow Straits ought to be hotter than in Davis' Straits. And such we find it, as far as our limited observations can be made available. The month of July 1851, at Cornwallis Island, was found to be three degrees warmer than the same month of the preceding year in a corresponding latitude on the east side of Davis' Straits. This difference is certainly small, but still it is on the favourable side; and when we associate with it the different structure of the rocks and also the diminished supply of vapour during the winter months, we have a faint approximation to the true cause why the glacier preponderates so largely in one direction, while it is entirely absent in another. The fact too that large sections of the coast-ice, before it was generally detached from the land, became dissolved by the streams discharging the melting snows of the North Georgian Islands into the sea, may be taken as an additional proof that the summer heat was positively higher than was necessary for the conversion of snow into water.

Glaciers.—The travels of Prof. J. Forbes and of Agassiz in the Alps have so fully established the true theory of the descent of glaciers, which is applicable also to Greenland, as to render any remarks on this head almost unnecessary. The introduction of extraneous matter into the substance of the ice to be borne along must be the same in every country (fig. p. 301, *a* & *b* (Sketch No. 2), and Sketch No. 7, *b*). And so also must be the deposition of moraines at the angles where the glacier begins to protrude beyond the land, whether they occur at the sea-level, or at rapid turnings at higher elevations. This deposition arises from the dissolution of a portion of the ice rich in earthy matter consequent upon increased freedom of exposure to the action of the sun, and also from mechanical displacement of the rocky matter by the advancing mass of the glacier. This was remarkably well seen at the north side of the Petowak glacier, near Cape Atholl, both at the sea-level and at an angle two miles further up the side of the glacier.

The concentric and wavy appearance of the glacier-surface so often noticed in the Alps, is remarkably well seen in the vicinity of Cape Saumarez (Sketch No. 7, *b*) and of Cape Alexander (Sketch No. 8, *b*), and also in Bardin Bay (Sketch No. 6, *c*).

Both Prof. Forbes and Agassiz agree in attributing the roughness and irregularity of the surface of the glacier to the inequalities of the bottom over which it has to pass, more especially in cases where the action of the sun has not been distributed irregularly by means of accumulations of extraneous matter. This is frequently exemplified in the Arctic regions; and, as in the Alps, large crevasses are

* Principles of Geology, Seventh Edition, chap. vi.

the result when a protruding mass is slipping imperceptibly over a convex or ledged surface *.

Although there certainly is a relation between the upper and lower surfaces of a plastic glacier, even when it may be upwards of 2000 feet in thickness, still I must confess that in my opinion we can scarcely attribute the regularly pinnacled appearance of many a large iceberg and magnificent glacier to this cause. Some glaciers and icebergs, again, are so flat and smooth on the upper surface, that one can hardly conceive a rocky bottom beneath a glacier to be equally smooth. On the north side of Cape Clarence, in the north shore of Jones' Sound, during the late voyage of the "Isabel," I observed that one portion of the surface of a flat but extensive glacier, that protruded several miles into Glacier Strait, was exceedingly smooth, while another portion of it was so rough and pinnacled that to walk over it would have been impossible. This roughness must be attributed to some peculiar atmospheric cause, or to the difference of temperature between the surface and the interior of the glacier.

Eight feet is the depth to which a minimum temperature of $-45°$, a monthly mean of $-30°$, or an annual mean temperature of $+2{\cdot}5°$ extended the freezing-point of water through freshwater ice on a lake of two fathoms' depth (Kate Austin's Lake) in lat. 74° 40′ and long. 94° 16′. If we can presume the heat-conducting power of ice formed on the surface of water, and of glacier-ice, to be the same, then the temperature of the interior of the glacier below the above depth, with the same minimum or mean annual degree of cold, would be about $+32°$. The surface exposed to any alternation of heat and cold, from the freezing-point to $-45°$ or many degrees lower, would necessarily become contorted and disturbed by contraction and expansion, even supposing its base or supporting part were standing still. Of this we had unexceptionable proofs in the condition of the surface of the ice on the lake already noticed. But when we take into account that the whole bulk of the glacier, except a few feet of its upper surface, retains its plasticity and continues its downward motion, it need not be wondered that the latter, hard and friable, assumes a broken-up appearance. This view, however, does not fully satisfy us, not being universally applicable.

Following the example of Mr. Christie, one of the Secretaries of the Royal Society †, during a winter in Barrow Straits, I performed a number of experiments by submitting water in a strong iron bottle to various temperatures, from $+32°$ to $-45°$. While the temperature to which the bottle containing the water was exposed did not descend more than eight or ten degrees below the freezing point, the

* This is very well seen in the glacier of Petowak, and also in a glacier at Cape Fitzroy, on the south shore of Jones' Sound. These crevasses are not unfrequently filled up with mud, &c. brought down by debacles and other means from the land on either side, and then they become frozen, thus cementing the whole mass firmly together, and perhaps forming part of the future iceberg so long as a few cubic feet of it remain undissolved.

† Sir Charles Lyell's Principles of Geology, Seventh Edition, p. 226.

column of ice, ascending through the orifice or "fuze hole," and always amounting to about one-tenth of the whole mass of water used, retained its cohesive property so perfectly, that without being broken, and although only half an inch in diameter, the whole apparatus weighing four to five pounds could be raised by its means, and sometimes even inverted. But at lower temperatures the ascending column escaped with a slight crepitating sound, and frequently with explosive reports, accompanied each by a sudden propulsion of a portion of it to a distance of several feet; it was so friable too that it separated into discs of half or a quarter of an inch in thickness, and sometimes crumbled to fragments between the fingers. The important points, relative to the plasticity of ice, contested some years ago by Prof. J. Forbes and Mr. Hopkins come within this field of research; they are well known, and need not be recounted here.

Icebergs.—From what has been observed in the Alps, it may be considered a settled question that the downward motion of the glaciers is constant and comparatively unaffected by low temperatures applied to the surface, especially when the depth of the solid ice amounts to several hundred feet. In the Alps, and even within the tropics, they travel great distances from the snow-clad heights, until gradually they frequently descend into the regions habitable by man, where they undergo dissolution by the increase of temperature. In Greenland, after descending into the sea through the valleys, they retain their hold of the land *, until the buoyant property of water upon ice comes into operation, and then they give birth to icebergs, sometimes of enormous dimensions †. The constant rise and fall of the tide exerts great power in detaching these floating ice-islands. By it, a hinge-like action is set up as soon as the edge of the glacier comes within its influence, and is carried on, although the surface of the sea for many leagues around is covered with one continuous sheet of ice. After summer has set in and somewhat advanced, the surface-ice either drifts away or dissolves, and then we have winds prevailing in a direction contrary to what they had been during the cold season of the year; and the result of this is a great influx of water into Davis' Straits, which causes tides unusually high for other seasons of the year, and which in their turn set at liberty whole fields of icebergs, then to commence their slow southward course. In August 1850 the number set free in a deep fiord near Omenak, North-east Bay, so occupied the navigable passage out of the harbour at that settlement, that the Danish ship which had but a few weeks previously entered the harbour was in great danger of being detained for the winter. In the same month in 1852, the whole of the coast southward from Melville Bay, extending over a space of 180 miles in length and probably 12 to 15 miles in breadth, was rendered perfectly unnavigable by any means whatever. When we sailed along that portion of the coast about the middle of August in

* Some of these glaciers of Northern Greenland push forward into the sea to the extent of from one to three miles.

† For the description of an immense iceberg, 200 feet high above the sea and two miles in length, see Sutherland's Journal, vol. i. pp. 61, 62.

the season of 1852, we were astounded by the constant booming sounds that issued from whole fields of floating icebergs, often bursting and turning over. To me the change appeared to be remarkable, for I spent the months of June and July of 1850 in company with a whole fleet of whalers there, sailing safely in the very place which now we could no more enter with our ship, than navigate her through the city of London half submerged in the sea, and all the houses tumbling about and butting each other as in an earthquake. At Cape York, one could count nearly two hundred icebergs in a semicircle of twelve miles, all of which appeared to have been quite recently detached from the glacier; and in the upper part of Wolstenholme Sound, the icebergs, that had come off from the three protruding points of the glacier entering it, were so closely planted together, that it was not without some difficulty and even danger we advanced among them although aided by steam.

Action of glaciers on the sea-bottom.—The effect of bodies of such dimensions on the rocks and mud at the bottom must be as extensive as it is important. While passing up the Straits early in the season, one rarely sees sea-weed floating in the water, but at a period somewhat later, after these natural reapers have sallied out to mow down their crops, we meet with whole rafts of the produce of the submarine forests of these regions floating down the Straits. The stems of *Laminaria* are often found abraded, and their roots contain shells and other animals, some of which appear to have participated in the violent action that liberated the plants they sought as a protection. In every part of Davis' Straits, from Cape Farewell to Smith Sound, on either side or mid-channel, from two to two hundred fathoms, wherever the dredge has reached the bottom, these animals have been found to exist, in spite of iceberg-action in its most intense form upon their rocky or muddy habitats. Ascidians and Cirrhipeds, and many other animals which attach themselves to the rocks at considerable depths, are often found. The Echinoderms, which we know are too slow in their motions to escape danger, swarm in those seas. A species of Sea-Urchin (*Echinus neglectus*) and brittle Stars have been taken up from depths varying from ninety to two hundred fathoms in Melville Bay, and from various other depths in all parts of the Straits. Shells also occur, but they are sometimes found broken, as some of the species of *Mya, Saxicava, Cardium, Pecten,* and many others, taken from depths of seven to one hundred fathoms, will show *. Except from the evidence afforded by plants and animals at the bottom, we have no means whatever to ascertain the effect produced by icebergs upon the rocks. Doubtless when they contain earthy and stony matter they must scratch and groove the rocks "as the diamond cuts the glass," and when they are impelled along a muddy bottom, they cannot fail to raise moraines and leave deep depressions in its otherwise smooth surface. But it will be well to bear in mind, that when an iceberg touches the ground, if that ground be hard and resisting, it must come to a stand; and the pro-

* For an account of the Fauna of these seas, see Appendix, p. cci. vol. ii. Sutherland's Journal.

pelling power continuing, a slight leaning over in the water, or yielding motion of the whole mass, may compensate readily for being so suddenly arrested. If, however, the ground be soft, so as not to arrest the motion of the iceberg at once, a moraine will be the result; but the moraine thus raised will tend to bring it to a stand. We can more readily conceive this from the fact that the power which impels icebergs is applied to about the upper third or fourth part of their whole bulk.

Another mode of action is sometimes exhibited by the iceberg, by which its triturating and ploughing force is locally brought into play with immense effect. Icebergs resting on the bottom, and situated at the edge of the fixed surface-ice (that which is attached to the land), when pressed upon by loose and drifting floes of large size, are frequently subjected to a rotatory motion, extending sometimes to three-fourths of a circle, or even a complete revolution.

The conveying power of icebergs is so well known to geologists, that I need make but few remarks on this subject. As a general rule, the source of all the foreign matter they contain is the land on both sides of the glacier. It may, however, be received from other sources. I have often thought that the fragments of a huge iceberg, acquiring a state of quiescence after separating into several masses in one of its fearfully grand revolutions, had turned up mud and other earthy matter from the bottom. This, however, is doubtful; for we can hardly conceive it possible that anything extraneous can adhere to hard and brittle ice passing rapidly through the water during the iceberg's revolution. Icebergs are sometimes floated so close along a bold and overhanging rocky coast, as to touch the perpendicular cliffs and to remove disintegrating fragments of the rock. Another, and probably the most common of these *unusual* modes, is from coast ice, which, impelled by the winds and tides, is often piled up with its load of rounded pebbles, sand, and mud against the sides of icebergs. The foreign substances thus cast upon the surface of an iceberg must necessarily be precipitated to the bottom at the first revolution it undergoes.

The quantity of rocky matter which ice is capable of floating away can be estimated from the specific gravity of both substances. Taking 2·5 as the density of granite and ·92 as that of ice, an iceberg half a mile in breadth, a mile in length, and 200 feet high above the water (dimensions, we may observe, by no means out of the average) will convey a load of one hundred and forty millions tons weight. Some of the icebergs seen in Davis' Straits are so charged and impregnated with earthy matter, that by inexperienced persons at a distance they may be mistaken for masses of solid earth. And we often observe large boulders, of perhaps one hundred tons each, lying on the surface of icebergs, or sometimes imbedded deeply in the ice.

By far the greatest number of these floating masses dissolve in Davis' Straits, and deposit their earthy contents throughout its extent. Some of them, however, find their way into the Atlantic, and appear disposed to push far to the southward into the temperate zone. As Sir Charles Lyell and others hav remarked, where the greatest

number of these undergo dissolution there the deposition of rocky matter is most active, consisting of angular and rounded fragments, together with sand and mud, a great part of which materials are probably from sources of very opposite character*.

Coast-ice.—Ice forming on the surface of sea-water is also well known as an agent of importance in conveying away to considerable distances the materials of the sea-coast. With strong gales the ice in the Arctic Seas is driven in upon the coasts with great force, and, if the bottom about the low-water mark is composed of loose gravel or mud, moraines are raised to a height of several feet. The wind ceasing and high tides proving favourable, the ice again withdraws from the coast, carrying with it large accumulations of the loose shingle of the beach, which it deposits in the surrounding seas, after travelling several hundred miles. The moraines it had raised are not wholly obliterated, and as winter proceeds to hem the coast with a fringe of ice, they cause an irregularity in the surface of the latter by the rise and fall of the tides, which results in a large portion of their contents, mud, sand, shingle, and perhaps also traces of animal and vegetable matter, being included in the new ice formation. This process ceases altogether only with the return of summer, and then the coast-ice, varying in thickness from two or three up to twenty or more feet, according to the degree of cold, the stillness of the water, and the extent of the rise and fall of the tides, is subject, in some localities at least, to the power exerted by debacles in loading it with foreign matter. Thus freighted, it withdraws from the shore when the straits and inlets open out, and drifts many hundred miles before it is dissolved by the action of the sun and the water, and yields itself and its carefully bound cargo to the sea. We find this occurring every season on the south shore of the North Georgian Islands; but from the testimony of numerous travellers†, it occurs on a magnificent scale at the entrances of the great American and Siberian rivers which discharge their waters into the Arctic Seas.

Polar Currents.—The necessity there is for currents into the Polar Seas to keep up their mean salinity will become obvious when we reconsider the vast amount of fresh water which enters them in the form of icebergs from the glaciers. That there are currents out of the Polar regions is sufficiently clear; were there no such currents, evaporation alone from the surface of the sea, the greatest part of which is generally covered with ice, would fail to remove the excess carried by the annual crop of icebergs; and then we should have an icy pile ever growing and gradually extending into the temperate zone. The difference of temperature observed by the navigator in the waters of the eastern and western shores of the North Atlantic, amounting as it does to nearly 30° of Fahrenheit's thermometer in lat. 59° during the warmest months of the year, affords the best possible proof of the existence of currents in the two directions we have indicated. In Davis' Straits, although on a much smaller scale, there

* See also Col. Sabine's Observations, Brit. Assoc. Sections, 1843.

† Principles of Geology, Seventh Edition, page 86.

is also a difference in the temperature of the sea on its two shores. On several occasions during the late expeditions in search of Sir John Franklin, while the ships were crossing that strait from east to west a fall of a few degrees was observed. This accounts pretty accurately for the fact that the east shore during a great part of the year keeps clear of ice, while the opposite is for the most part encumbered; and the greater mildness of the climate on the east side arises from the same cause. Allusion need not be made here to the late President's Paper on the temperature of the North of Europe, as the analogy between the North Atlantic and Davis' Straits with respect to currents will easily occur to us.

The specific gravity of the water also assists in determining the direction of the currents in the Polar Seas. During Captain Inglefield's late voyage, it was found to decrease as we approached Cape Farewell and advanced northward and westward in Davis' Straits*.

In the Atlantic, long. 30°, lat. 56° 30′, 24th October, 1852, the natural temperature being 48° Fahr., the density at 60° Fahr. was 1·02808.

At Cape Farewell on the 31st July, natural temperature 33°, density 1·0245.

Davis' Straits, lat. 68°, sixty miles off the coast of West Greenland, August 11th, natural temperature 40°, depth fifty fathoms, density 1·0265.

Close to Cape York, lat. 76°, August 21st, natural temperature 30°, sea-water-ice and icebergs abundant, depth fifty-four fathoms, density 1·0215.

About two miles off Cape Alexander, Smith's Sound, lat. 78° 20′, long. 71°, August 27th, natural temperature 32°, no ice but in the vicinity of the glaciers in the coast (Sketch No. 8, *b*), depth 154 fathoms, density 1·02516.

In Jones' Sound, lat. 76° 11′, long. 83°, September 1st, natural temperature 30°, sea-water-ice and icebergs present but not abundant, density 1·02451.

About two miles off Cape Fitzroy, Lady Anne's Strait, Jones' Sound, lat. 75° 35′, September 2nd, natural temperature 30°, sea-water-ice thirty to forty feet thick, most abundant, no bottom, 150 fathoms, density 1·0235.

And off Cape Walsingham, lat. 66° 34′, long. 60° 50′, October 12th, natural temperature 30°, density 1·0245.

Slight as the differences in these densities may appear to be, in my own estimation they are assignable to no other cause than the increased saltness of the water on the east shore, consequent upon a tendency of the water to advance *from* the southward, and the diminished salinity resulting from the dilution of the water moving *to* the southward. The above cases, taken by chance, I have cited from the observations made every day at noon, and although the results at Cape York and Cape Farewell do not bear out the impression conveyed by the whole, we may still presume that impression to be safe in a general point of view. The exception at Cape Farewell arises in all probability from a diversion of the great Arctic current which flows round that promontory, and carries into that part of the Straits ice and drift-wood which may have come southward from great distances in the Greenland Seas; and in this respect it may be taken as a proof of the dilution of the water of that current consequent upon its burden of comparatively freshwater ice. Again, the exception at

* Compare Forchhammer's Observations on the Currents and Salinity of the Polar Seas in the Reports and Transactions of the British Association, 1846.

Cape York may arise from some local cause, such as the presence of an unusually large number of icebergs. On our own coasts the mean density of the sea is often disturbed by the discharges of rivers and small streams. An evening of rainy weather in November of the past year reduced the density of the sea in Stromness harbour from 1·0285 to 1·0235, and eighteen hours of heavy rain on the 17th of the same month reduced that of the water of St. Margaret's Hope, Frith of Forth, from 1·0245 to 1·0185. Before, however, this theory of a northerly seeking current in Davis' Straits along the eastern shore can be accepted, we must get over the difficulty arising from the position of the great Arctic current in the North Atlantic. This current sweeps southward across the entrance of Davis' Straits and prevents the ingress at the surface of any water from the Atlantic, except such as the current itself would supply. The Rev. Dr. Scoresby suggests the idea that two currents may arise from the existence of two strata of water varying in temperature*. The question then arises as to the order of superposition. If sea-water independent of its saline ingredients follows the law of expansion peculiar to water from 40° to 32°, one current at a temperature of 36° may pass over another at 44°, and if we separate the extremes eight degrees more, the coldest is still the most buoyant, for, even although it is sea-water, if in a state of tolerable quiescence a portion of it will have become congealed. It is a well-known fact that the process of congelation separates the saline from the watery particles. I have often observed sea-water freezing when the immersed thermometer stood at 32°, and the ice produced at the time was found to contain little more than a trace of saline matter. But there seems to be no reason why this separation should be confined solely to the act of congelation, since it is owing to the universal law of contraction observed in obedience to cold by, I believe, everything in nature except water itself, and that only between the temperatures of 40° and 32°. This may appear somewhat at variance with the experiments of Erman, as quoted by Sir Charles Lyell†; the latter, however, acknowledges the possibility of the colder and more diluted water of the Arctic current passing over the warmer and more saline waters of the Gulf Stream. Until our knowledge of the physical changes peculiar to these high latitudes extends, such phænomena as the above must remain more or less obscure; at present we may rest assured that a meeting and commingling of waters differing in point of saltness and temperature takes place in the entrance of Davis' Straits, and to this causing sudden and decided meteorological changes may be attributed, in great measure, the extreme violence of the storms experienced by navigators when they approach Cape Farewell.

Sea-bottoms and Soundings.—Presuming then upon the existence of currents into the Arctic Seas which may assist the action of the sun in dissolving icebergs and sea-water-ice, we are in a position to consider the extent and character of deposits and accumulations of drift material or "till" now forming in the track of these conveying

* Sir Charles Lyell's Principles of Geology, 7th edit. page 97. † *Ibid.*

agents. At the confluence of two opposite currents the largest amount of foreign matter will be deposited, for there icebergs and coast-ice are brought to a stand in the eddies, and are liable to be detained until they are dissolved. In such cases submarine ridges and mounds begin to grow above the general level of the sea-bottom, and they may continue to increase until the surface of the water is reached.

A bank in latitude 67° and 68° off the coast of West Greenland, well known to the whaling and cod-fishing vessels by the name "Reefkoll or Riscoll Bank," seems to answer this description. The depth of water on the highest part of it does not exceed fifteen fathoms. It appears to be composed of angular fragments of rock and other materials brought down by icebergs and coast-ice. This, however, can only be inferred from the sounding line, and from the rough usage to which the lines of the whalers are submitted when they attack and get fast to their prey in its neighbourhood. Its limits can be defined almost at all times by the clusters and groups of small icebergs that take the ground upon it; and like other banks of a similar character but less extensive on the same coast, it is exceedingly fertile in shoals of cod-fish and halibut which frequent it in the months of May, June, July, and August. These and other fishes, including myriads of sharks, may pass the whole year upon it; but this we have not as yet had the means of putting to the test.

In other parts of Baffin's Bay and Davis' Straits the bottom is composed of fine mud, sand, rounded and angular fragments of rock, shells, and marly deposits resulting from minute subdivision of calcareous, phosphatic, and siliceous animal and vegetable matter, all of which have been brought up in the dredge. In the neighbourhood of islands composed of crystalline rocks the bottom was often found to be rocky; but, as might be expected, numerous depressions were filled with sand and shells. From a depth of twenty-five to thirty fathoms at the Hunde Islands, South-east Bay, lat. 68°, the dredge passed over a loose and softish deposit, and brought up a quantity of dark-coloured rather finely divided matter resembling peat, which appeared to have been the result of the decomposition of *fuci* at the bottom. In some cases the roots, being the hardest and most enduring parts, could be detected.

Organic Remains deposited in the Arctic Seas.—Diatomaceæ are exceedingly abundant within the Arctic Circle. Mud from almost every locality has not failed to yield considerable varieties; but the most productive source is the surface-ice when undergoing decay. It often occurred to me that these microscopic forms may be accumulating in a state of great purity, and to a considerable extent, in some of the highly favourable localities so common in Davis' Straits. In many of the sheltered bays, where the water is still and the ice dissolves without drifting much about, a brownish slime, consisting of nothing but these forms, occupies the whole surface of the water among the ice, which, after the latter has all disappeared, becomes rolled into rounded pellets by the rippling of the water, and

ultimately sinks to the bottom*. This process of deposition extending over thousands of years would produce accumulations scarcely second to those of the "berg-mehl" of Sweden, or of the tripoli of the Isle of France.

In addition to such varied materials as we have indicated, the accumulation of "till" will contain abundant remains of animals high in the order of creation. Of all parts of the ocean this is the most frequented by the large cetacea and the seals. The numbers of the former are very great, and that of the latter almost beyond comprehension. Their bones must be strewed on the bottom, and thus they will become constituents of the growing deposit. It may also contain the enduring remains of other animals. Every Arctic traveller is aware of the fact that Polar bears are seen on the ice at great distances from the land; and my own experience bears testimony to the fact that not unfrequently they are found swimming when neither ice nor land is in sight. The Arctic fox and, I believe, also the wolf, and certainly the Esquimaux dog, animals not generally known to take the water, are set adrift upon the ice and blown out to sea, where they perish when the ice dissolves. And cases are known, although perhaps not recorded, in which human beings have been blown away from the land upon the drifting floes, and never heard of. Two persons to my own knowledge have thus disappeared from the coast of West Greenland. One of them, however, reached the opposite side of Davis' Straits, where he spent the remainder of his life among his less civilized brethren. And the ships engaged in the whaling on the west side of this Strait sometimes have a deed of humanity to discharge by taking from the drifting pack-ice a group of natives. I have not alluded to the remains of reindeer and other ruminants of these regions, for the reason that I believe they frequent the ice much less than those that have been mentioned, and consequently are much less liable to be drifted away. It is highly probable, however, that their bones, as well as human remains and works of art, sometimes reach the bottom of the Arctic Seas, the ice of rivers and deep inland bays being the conveying agents.

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4. *On* Arctic Silurian Fossils. By J. W. Salter, Esq., F.G.S.

A considerable number of limestone fossils were brought home by the officers and gentlemen engaged in the late Arctic Expedition (1850–51), which have added very materially to our knowledge of the geology of those polar regions.

The rocks along the coasts of Barrow Strait and the shores of Prince Regent's Inlet were already partly explored by Parry, and

* For an account of the Diatomaceæ of these seas, see Prof. Dickie's "Notes on the Algæ," in the Appendix to Dr. Sutherland's Journal, vol. ii. p. cxcv. *et seq.*

described by Prof. Jameson and Mr. König; and a few fossils, brought away in ballast from Prince Leopold's Island by Sir James Ross, had been detected at Woolwich by Capt. James, R.E., and mentioned in Prof. Ansted's Manual. But the present collections from the entrance of Wellington Channel are far more extensive than those before made; and the localities have been exactly marked. Her Majesty's squadron, under command of Capt. Austin, collected specimens of fossiliferous limestone in Assistance Bay, Cape Riley, and Beechey Island, and in Griffiths' and Somerville Islands; and some travelling parties brought home a specimen of the same limestone with fossils from Cape Walker, still further to the south-west. Our thanks are especially due to Capt. Ommanney and Mr. Donnet, who have presented their specimens to the Museum of Practical Geology, and to Sir John Richardson, who has permitted us to examine those brought home by Mr. Pickthorne of the 'Pioneer.'

In addition to these, Capt. Penny and his companions discovered that the same rock with fossils extends up both sides of the strait, and covers the islands at the mouth of the newly discovered Queen's Channel. These researches were prosecuted more particularly by Dr. P. C. Sutherland, assisted very willingly by the seamen; and to Sir John Richardson we are indebted also for the examination of these fossils.

Of the following list of organic remains (described in the Appendix to Dr. Sutherland's Journal*), some are known European fossils. Among these the common Chain-coral (*Halysites catenulatus*), the *Favosites Gothlandica* and *F. polymorpha*, and the *Atrypa reticularis* are well-known cosmopolitan species. There are some others, more doubtfully European forms; and three, among which is the *Pentamerus conchidium*, appear to be identical with Swedish species in the Wenlock limestone of Gothland. The rest are new to me, either as occurring in Europe or America.

The general resemblance with the fossils of our own Upper Silurian rocks is very considerable; and, in the absence of many characteristic Lower Silurian genera, the identity of several species with Upper Silurian forms, and the great prevalence of corals, I think we are quite warranted in placing these strata in the Upper division of the Silurian system.

The shores at the entrance of Wellington Strait, at Cape Riley, Beechey Island, Cornwallis and Griffiths' Islands, contain the following fossils, most of which are figured in the work above-quoted:—

Crustacea.

1. Encrinurus lævis, *Angelin*? (Sutherland's Journal, Appendix, pl. 5. fig. 14). In all probability a Gothland species. The arctic fossil differs in having two more ribs on each side the tail.
2. Proetus, sp. (*l. c.* pl. 5. fig. 15).

* Journal of a Voyage in Baffin's Bay and Barrow Straits in the years 1850–1851, &c. 2 vols. 8vo. London, 1852. Appendix, p. ccvii.

3. Leperditia baltica, *Hisinger*, sp.; *var.* arctica, *Jones* (*l. c.* pl. 5. fig. 13). Also a Gothland fossil. Mr. T. R. Jones considers it to be a variety only.

Mollusca.

4. Lituites, n. sp. Allied to *L. articulatus*, Sow., but with more numerous whorls.
5. Orthoceras Ommanneyi, n. sp. (*l. c.* pl. 5. figs. 16, 17).
6. ——, species, with distant septa and central siphuncle.
7. ——, species, imperfect, but distinct from both the preceding.
8. Murchisonia, sp. (*l. c.* pl. 5. fig. 18). Very like *M. gracilis*, Hall.
9. ——, larger species, with numerous whorls (*l. c.* pl. 5. fig. 19).
10. Euomphalus, a small species.
11. Modiola (or Modiolopsis). An oval and flattish form.
12. Strophomena Donneti, n. sp. (*l. c.* pl. 5. figs. 11, 12).
13. ——, sp. The same as at Leopold's Island.
14. Orthis; large flat species. Griffiths' Island.
15. Spirifer crispus, *Linn.*? (*l. c.* pl. 5. fig. 8). It may be the young of the next.
16. ——, a species very like *S. elevatus*, Dalm.
17. Chonetes lata, *Von Buch*? Not perfect enough to identify.
18. Pentamerus conchidium, *Dalm.* (*l. c.* pl. 5. figs. 9, 10). Both coarse-ribbed and fine-ribbed varieties: larger than ordinary Gothland specimens.
19. Rhynconella Phoca, n. sp. (*l. c.* pl. 5. figs. 1–3). Allied to *T. camelina*, Von Buch, but with a narrow sulcus down the larger valve.
20. ——, sp. (*l. c.* pl. 5. fig. 4). An ordinary plaited species.

Radiata.

Encrinites are so abundant at Cape Riley, that in several places the rock is composed entirely of their detritus. A species of *Actinocrinus* is the only fragment at all recognizable.

Corals are very abundant, twenty or more species having been observed. Among them there are—

21. Ptychophyllum. A fine fossil, three inches across.
22. Cystiphyllum.
23. Cyathophyllum.
24. Strephodes Pickthornii, n. sp. (*l. c.* pl. 6. fig. 5). Single calices, plentiful.
25. ——? Austini, n. sp. (*l. c.* pl. 6. fig. 6). A large aggregate coral, very abundant, and like the *Astreæ* of the present seas. It is possibly a *Clisiophyllum.*
26. Clisiophyllum, sp. (*l. c.* pl. 6. fig. 7). A beautiful coral.
27. Aulopora, sp. Too imperfect to identify.
28. Favistella reticulata, n. sp. (*l. c.* pl. 6. fig. 2). Like *F. stellata*, Hall, but with much shorter lamellæ.
29. —— Franklini, n. sp. (*l. c.* pl. 6. fig. 3). Lamellæ quite rudimentary.

30. Favosites polymorpha, *Goldfuss* (*l. c.* pl. 6. fig. 9). Both branched and amorphous varieties.
31. —— Gothlandica, *Linn.* Diaphragms closely set in this variety.
32. ——, sp. With three rows of pores on each prism.
33. ——, sp. A very remarkable cylindrical species.
34. Cœnites (Limaria), sp. Abundant at Beechey Island.
35. Halysites catenulatus, *Linn.* (*l. c.* pl. 6. fig. 11). The common Chain-coral, of all sizes.
36. Syringopora, sp. Much like some British species.
37. Heliolites (Porites). A rare fossil in these limestones.
38. Columnaria Sutherlandi, n. sp. (*l. c.* pl. 6. fig. 8). Found at Beechey and Seal Islands.

Proceeding up Wellington Channel;—at Point Eden, on the south side of Baring Bay, Dr. Sutherland found a new coral—

39. Arachnophyllum Richardsoni, n. sp. (*l. c.* pl. 6. fig. 10). Like some carboniferous forms.

And at the south-west end of Seal Island, a rock in Baring Bay, in white crystalline limestone—

Encrinurus lævis. Above-noticed.
Leperditia baltica, *Hising.*, sp. *Var.* arctica, *Jones.*

40. Atrypa reticularis, *Linn.* (*l. c.* pl. 5. fig. 7). Of small size; abundant.
41. Rhynconella Mansonii, n. sp. (*l. c.* pl. 5. fig. 5).
42. —— sublepida, *De Vern.*? (*l. c.* pl. 5. fig. 6).
43. Fenestella (*l. c.* pl. 6. fig. 1). Small species, same as at Leopold Island?
44. Crotalocrinus. Stem only. Like *C. rugosus*, Miller.
45. Calophyllum phragmoceras, n. sp. (*l. c.* pl. 6. fig. 4). A cup-coral with large flat diaphragms.

Dr. Sutherland followed the margin of the strait to its north-eastern angle in lat. 76° 20′, and Capt. Stewart continued along the shore until he reached the new Queen's Channel, long. 97°. Along the whole coast the same limestone rocks were visible; and from its peculiar uniform castellated appearance, it could be traced by the eye to extend still further up the sides of that inlet. In the mean-time Capt. Penny and his crew were exploring the islands which separate this channel from the Wellington Strait; and both in Hamilton Island and Deans Dundas Island abundance of fossils were seen. The necessity of abandoning their boat prevented their bringing them away; but one of the seamen, James Knox, contrived to roll up a Trilobite and a Bellerophon in the corner of his shirt, and bring them back to Dr. Sutherland. They were from Dundas Island, in lat. 76° 15′, the most northerly point of the New Continent from whence fossils have been brought. One of them is the

Encrinurus lævis, before mentioned; the other,

46. Bellerophon nautarum, n. sp. (*l. c.* pl. 5. fig. 20). So named in honour of the crews of the 'Lady Franklin' and 'Sophia.'

Returning to Barrow Straits. The ballast from Leopold's Island, before quoted, yielded—

Favosites polymorpha. Abundant.
—— Gothlandica.
Fenestella, sp. Probably the same as above.
Strophomena, sp. Same as No. 13.
Rhynconella Phoca. As above.
—— sublepida, *De Vern.* The ribs in the middle of the shell are not quite of the same size as in the Ural specimens, and seem more prominent.
47. ——, sp. Simple plaits. Distinct from No. 20.

The existence of this great formation of Upper Silurian limestone along the shores of Prince Regent's Inlet is rendered all but certain from the notes furnished by Prof. Jameson and Mr. König in the Appendices to Capt. Parry's Voyage. From their accounts, the coasts are occupied by a transition limestone of an ash-grey or yellowish and grey colour, often fœtid, and sometimes crystalline or compact. It is described as filled with zoophytes and shells, and in certain parts, as noticed by Mr. König, quite made up of the detritus of Encrinites, the fragments of which are so comminuted that it might readily be mistaken for a granular limestone. He also found in it the chain-coral.

Prof. Jameson gives a list of organic remains from Port Bowen, which, by modernizing the nomenclature of the fossils, would agree well with those from the north shore of Barrow Straits, and indeed he has himself identified them. And he mentions that this same rock extends eastward to Cape York, Admiralty Inlet, and even occurs at Possession Bay, while in a southerly direction it was found as far as the Regent's Inlet was explored. We have seen that a similar limestone occurs at Cape Walker, Russell Island; and from the general low character of the shores that stretch to the west (explored lately by Capt. Ommanney), it is probably continued along them.

The north-eastern shores of Lancaster Sound are composed, at least in part, of igneous and crystalline rocks; but from the commencement of the table land at Powell's Inlet all along the coast to the Wellington Channel, a uniform appearance of the shore (the cliffs appearing like fortifications) indicates the presence of the same tabular strata of limestone. Dr. Sutherland, who is well acquainted with the appearance of the limestone cliffs, and who had the advantage of communicating with the different exploring parties, is without doubt of its continuity along this coast.

Again: the limestone of Melville Island, according to Mr. König, contains *Favosites* and *Terebratulæ*. Dr. Conybeare adds to them *Catenipora* and *Caryophylliæ*; and this is just the aspect which the fossils of the limestone we have described would present on a cursory examination. In Melville Island, however, it is connected with a sandstone and coal formation, with a carboniferous flora; and as this sandstone contains *Trilobites*, *Encrinites*, and *Aviculæ*, we may hesi-

tate, in the absence of authentic specimens, to extend the Silurian limestone so far*.

We may now then definitely colour the shores of Wellington and Barrow Straits, except the eastern entrance of the latter (which is occupied by igneous or crystalline rocks), as Upper Silurian; and on the return of the expedition under Capt. Belcher, the limits of this formation will be no doubt greatly extended.

I may mention that coal or lignite was picked up at Byam Martin Island, and that a fragment of it occurred in the detritus, 350 feet above the sea, at Kate Austin's Lake, Cornwallis Island. Also at Griffiths' Island and Browne Island fragments of iron were found.

And, in conclusion, it is worth while to observe the occurrence of pleistocene deposits with marine shells of existing Arctic species (*Mya truncata, Saxicava rugosa*, &c.), which were found on every elevation up to 500 feet on Beechey and Cornwallis Islands.

June 15, 1853.

Robert Philips Greg, Jun., Esq., Edward Wray Winfield, Esq., B.A., and Prof. R. Harkness were elected Fellows.

The following communications were read:—

1. *On some* Sections *in the* Oolitic District *of* Lincolnshire. By John Morris, F.G.S., Professor of Geology and Mineralogy, University College, London.

[Plate XIV.]

The following observations relate to a series of Sections exposed during the progress of the cuttings of the Great Northern Railway in Lincolnshire, and which are considered to be of sufficient interest to be laid before the Society, inasmuch as they afford some novel points connected with the Oolitic series, and also some interesting phænomena relating to the Drift. As many of the sections are now covered up, and as they occurred in a district where good and deep sections are comparatively rare, a brief record of their general character will be useful to those whose future investigation may lead them to examine the local phænomena more in detail.

The line of country traversed by the railway between Grantham and Peterborough being occupied by a portion of the lower oolites (which are here diminished in breadth), exposes the following members of the oolitic series, some of which have not been previously noticed as occurring in that district, in ascending order:—Lias, Inferior Oolite,

* In the collection of rocks from Melville Island, in the Society's Museum, a specimen of the compact limestone and a coral (*Favistella Franklini*) occur: the latter was "collected by Lieut. Liddon, second in command in the Expedition of 1819-20," and presented by Dr. Granville, F.G.S.

Great Oolite, a series of shales, sands, and clays (the equivalent of the Upper Sandstone and Shale of Yorkshire), Cornbrash, Kelloway Rock, and Oxford Clay. Covering some portions of these, and in considerable thickness, is a great mass of the northern drift, besides which are thick accumulations of gravel and remains of a fluviatile deposit.

The beds referable to the Drift period which it is intended to describe in the first part of this paper, viz. the superficial detritus occurring in irregular patches on the oolite, the boulder-clay or northern drift, and the gravel beds of the valleys, &c., will be noticed as they occur from north to south, commencing from near Grantham.

Part I. The Drift.

Section 1. *Little Ponton Cutting.*—The first indications, in these sections, of deposits connected with the Drift era (and probably towards the termination of it) are met with at the Ponton Cutting, south of the Witham valley, where the oolites are frequently dislocated, the dislocated portions lying at high angles and very irregular. The oolitic rocks, moreover, are here scooped out into hollows of considerable size, sometimes 100 yards in length and 50 feet in depth: these cavities are extremely irregular in form and have a general direction of N.E. and S.W., and apparently follow the direction of the great jointings or fissures of the rock. They are occupied by more or less stratified masses of clays, and sands with pebbles, with occasional rounded boulders of sandstone. Interstratified with these, but more especially towards the upper portion, are thick layers of fragmentary oolite, identical with the enclosing rock, and sometimes, in the lower part, large blocks of the same rock.

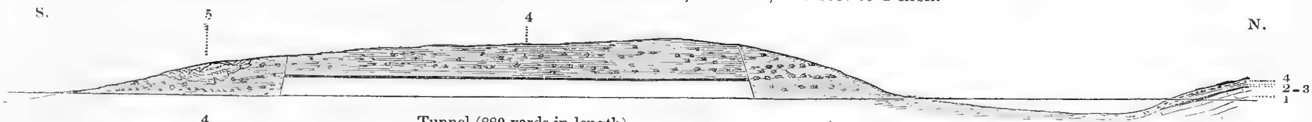
Section 2. *Between the two Ponton Cuttings.*—The first appearance of the northern drift is met with in a small section, about 6 feet deep and about 160 yards in length, between the two Ponton Cuttings. The drift here overlies the upper part (shelly beds) of the Great Oolite.

Section 3. *Great Ponton Cutting.*—The surface of the oolite is here excavated by similar hollows to those described in the Little Ponton Cutting, and these are also occupied by a similar debris which is distinct from and probably posterior to the northern drift.

At the southern end of this cutting the drift is again met with. Here a patch of the drift is exposed, 380 yards in length at its upper part and 160 yards at the base (the depth of the cutting being 20 feet), and overlying the shelly beds of the Oolite, which here dip to the S. at a moderate angle (1, 2, 3 in fig. 1). Passing a deeply-denuded valley in the drift, we come to a hill composed of the same formation, through which a tunnel is excavated (see fig. 1). The summit elevation of this hill of drift above the datum line is about 500 feet, and the drift here forms nearly the highest ground of the district. At the northern extremity of the tunnel the drift appears to be divisible into two portions. The upper part, about 25 feet thick, consists of light grey sandy clay, full of angular and rounded flints, some 2 feet in diameter, and rolled fragments of chalk, vary-

Fig. 1.—*Section of the Drift at the South End of the Great Ponton Cutting, and at the Tunnel.*

Scale: Horizontal, 15 chains to 1 inch; Vertical, 210 feet to 1 inch.



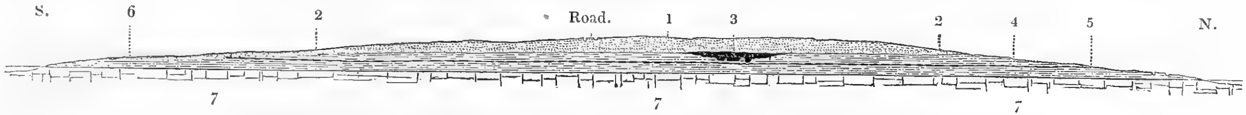
1. Oolitic rock of the district.
2. Ferruginous band; 1 foot thick.
3. Grey sand and shales; 6 feet.
4. Boulder-clay.

4 *a*. The lower part of the boulder-clay, with less chalk and flint detritus and fewer boulders.

5. Mass of oolitic rock in the Boulder-clay.

Fig. 2.—*Section of the Gravel, Freshwater Bed, and the Oolites at Casewick Cutting.* Length 39 chains.

Vertical scale 120 feet to 1 inch.



1. Gravel and sand, in wavy seams.
2. Sand and fine gravel with *Belemnites*, &c.
3. Freshwater deposit.
4. Upper sandy part of the Oxford Clay.
5. Sandy rock (Kelloway).
6. Dark, laminated Oxford Clay.
7. Cornbrash, along the base of the Cutting.

ing in size from 8 to 12 inches in diameter to pebbles of the size of a pin's head. The clay also contains large boulders of oolitic and other rocks, arranged in somewhat parallel lines, the former being very abundant. The lower part, 30 feet thick, consists of dark bluish grey tenacious clay, with traces of chalk and flints, and but few boulders. These latter are generally large and much rolled, and have been derived from the Oxford clay, oolites, marlstone, and lias; there are also pebbles of mountain limestone, granite, and other rocks; and interspersed with these are numerous liassic fossils, as *Ammonites, Belemnites, Gryphæa, Pholadomya*, &c. At the junction of these two divisions the boulders and pebbles occur in greater abundance, lying on an apparently eroded surface of the lower drift, which is readily distinguished from the upper division by the comparative absence of chalk and flint.

Emerging from the south end of the tunnel, which is 880 yards in length, we see the drift on either side of the cutting buoying up an enormous irregular mass of oolitic rock, through which the cutting has passed (see fig. 1, 5). This mass of rock is 430 feet long, and, at its deepest part, 30 feet thick; it is much broken and disturbed, but the parts retain to some extent their relative position, and belong to the lower portion of the oolitic beds of the district: the surface is continuous with the hill slope, and is here and there penetrated by intrusive drift; the lower part is eroded and waterworn. The depth of the underlying drift exposed at the lowest part between the broken rock and the level of the railroad is about 7 feet. Unfortunately the character of the neighbouring surface is so much obscured, that it is difficult to estimate the lateral extent of this great mass of disturbed oolite, which, although so distinctly isolated, retains sufficient uniformity of character to lead us to infer that it has not been far removed from its original site. The drift is here of similar character to the upper portion at the north end of the tunnel, and is peculiarly marked by boulders (oolitic chiefly) more or less horizontally arranged, and some of them underlying the uplifted mass of oolite.

Section 4. *Basingthorpe Cutting.*—Crossing another denuded drift valley, we come to the Basingthorpe Cutting, which extends for about one and a half mile through drift similar to the above. The larger boulders are more abundant; thirty to forty were counted in about sixty yards. They varied in size from 1 to 3 or 4 feet; one however, a micaceous sandstone, with fossils, much grooved and striated, measured 6 feet 9 inches in its longest diameter and 3 feet in depth. They are generally more or less square in form, and lie on their flat side, are sometimes polished, and frequently grooved or striated; the striæ are restricted to their flat surfaces, and are not found on the edges. The boulders assumed, as before noticed, a horizontal arrangement, somewhat following the contour of the surface of the ground. The larger masses consist of micaceous sandstone containing fossils (marlstone and cornbrash), besides which are many rounded and angular flints (sometimes grooved), lias septaria, greenstone, mountain-limestone, coarse sandstone, lias and chalk belemnites, and other fossils; occasionally we meet with local patches

containing comminuted chalk and flint. Another peculiar feature of interest is the occurrence of large angular masses of soft stratified sand, apparently removed from an upper portion of the oolitic series of the district.

This upper division of the Drift is of somewhat lighter colour than the lower, and its boulders are more numerous and larger than in the latter, and the chalk detritus is more abundant, but the line of separation does not appear so distinct as in that at the northern end of the tunnel, as above described. At the south end of this cutting the drift was observed to repose on a decomposed band of the oolitic rock.

Section 5.—As far as the Railway sections are concerned, the drift is last seen in a small cutting a quarter of a mile south of the last-described, but it occupies the adjacent valleys north and south of this point.

The object of this paper being simply to describe the local phænomena of the Drift exposed by the railway cuttings, the general arrangement of the Drift, the position of its boulders, and the peculiarities of the isolated mass of rock above described are not further treated of; but the author has to observe, that by numerous traverses, both on the east and west of the line, he has found the Drift covering a considerable extent of country, and apparently ranging as a band about six miles wide, in a N.E. and S.W. direction.

Casewick Cutting (fig. 2).—*Freshwater beds*.—The Casewick Cutting traverses oolitic rock, which represents the Kelloway Rock and Oxford Clay. These strata are overlaid by a deposit of gravel 7 or 8 feet thick. Towards the central part of the cutting a freshwater deposit is intercalated between the oolite and gravel, occupying an excavation in the surface of the former. This deposit is about 30 yards in width, and it has an average thickness of about 8 feet, and varies in thickness and character on each side of the cutting. It consists in the upper part of grey sandy clay, 2 feet; brown sandy clay and veins of gravel, $1\frac{1}{2}$ foot; a layer of peaty clay with fragments of plants and shells, $1\frac{1}{2}$ foot; dark sandy clay, with plants and shells, pebbles of chalk and flint, and portions of the northern clay drift in fragments. The base of the deposit is extremely irregular in outline (see fig. 2, 3), and the surface of the oolitic stratum is slightly disturbed and re-aggregated, as it is throughout the cutting. The following is the list of shells* and plants obtained; no bones, however, were observed :—

Bithinia tentaculata, and opercula	Plentiful.	Limneus pereger......	Rare and immature.
Valvata piscinalis	Plentiful.	Succinea putris	Rare and immature.
—— cristata	Rather rare	Ancylus fluviatilis ...	Rather plentiful.
Planorbis marginatus	Rare.	Veletia lacustris	Rather plentiful.
—— carinatus	Rare.	Cyclas cornea	Rare: fragments.
—— imbricatus	Only one.	Pisidium amnicum ..	Rather rare.

* The above list has been corrected by Mr. Pickering, who also kindly examined some portions of the clay from this deposit. To Mr. T. R. Jones I am obliged for determining the above-mentioned Cyprides.

Pisidium pulchellum	Mostly immature.
—— pusillum	
—— obtusale?	
Helix hispida	Rare.
—— pulchella	Only two.
—— aculeata (young)	Only one.
Carychium minimum	Only two.
Cypris (small species)	One valve.
? Candona lucens (young)	One valve.
Candona reptans	Three valves.
Spine of Echinus	These are derived from the Oxford Clay.
Belemnites	
Arca	
Cerithium	
Other casts and fragments of marine animals	
Seeds and other vegetable remains, as Ceratophyllum, Equisetum, &c.	

The freshwater deposit on one side of the cutting appeared to be intercalated with the superincumbent gravel, but on the eastern side there appeared a well-defined line between it and the overlying gravel, as if the freshwater deposit had been eroded; the gravel forming a continuous and uniform covering over this bed and the adjacent sandy and argillaceous strata, in a depression of which the freshwater bed had been previously accumulated. The gravel deposit consists chiefly of rounded and angular flints, rolled quartz pebbles, and a few other rocks, as oolite, &c., and some small sandstone boulders, irregularly stratified with occasional layers of small pebbles, seams of clay and loam, and others much mixed with a chalky paste, the larger pebbles occurring at the base; the gravel overlies 3 feet of greyish brown sandy clay, containing fragments of *Belemnites* and *Gryphæa*, with veins of gravel at the upper part, which is irregular and wavy.

Three miles to the westward, in the valley of the Gwash, another freshwater deposit, about 6 feet thick, intercalated with gravel, has been met with; it contains land shells, &c., and bones, and may be of slightly later date than the one above described.

Banthorpe Cutting.—Valley gravel.—The gravel noticed in the previous section again occurs at the northern end of the Banthorpe cutting: and although at that spot of limited extent, and abutting against the side of the hill, it forms a portion of a deposit which is of considerable extent and thickness, sometimes attaining 20 feet, and occupying chiefly the sides of the valleys and the upper surfaces of the lower grounds through which the present drainage is effected. This deposit consists of coarse rounded gravel of sandstone, oolite, and flint, with occasional angular fragments, a few small boulders, and interspersed patches and seams of sand; the whole deposit being coarsely stratified, and in some parts exhibiting vein-like markings of chalky matter. This gravel occurs over a considerable area in this district; it may be observed at Ponton, near Little Bytham, and around Uffington; it must not, however, be confounded with the smaller and more angular gravel of the present river valleys.

The age of the Casewick deposit above described, which is considered to be posterior to the boulder-clay, may be related to those found in the eastern district, as at Holderness, &c., and probably also to that of Mundesley, described by Sir C. Lyell as occurring

towards the close of the Drift-clay period and subsequently covered by beds of gravel and loam; Sir Charles in that case considering the freshwater stream to have been of sufficient force to counteract the causes by the influence of which the boulder-clay was accumulating in the contiguous spaces. The Casewick deposit affords no evidence of a similar nature.

In estimating the influences which have produced the phænomena, a portion of which only are disclosed by the above sections, it will be necessary to consider the general disturbances which have affected the district and the changes it has undergone, viz. the origin of the great transverse valleys, as the Nen, Welland, Witham, and Ouse—the scooping out of the channels and valleys anterior and posterior to the Northern Drift—the overspread of the Drift itself—the dislocation and undermining the oolitic rocks, and their subsequent depression into the adjacent valleys—the re-elevation of land; its effects—the accumulation of freshwater strata—the subsequent covering of the valleys and low grounds by thick gravel deposits; their partial elevation and denudation, and the final formation of the present valleys. These phænomena are intimately connected with and succeeded each other, producing the physical contour of the present surface, by which the drainage of the district has been permanently effected.

Part II. The Oolites.

Between Barkstone and Grantham, including the Peascliff Tunnel, the railway traverses the lower lias, marlstone, and a part of the upper lias, but no detailed descriptions are here given; the sections exposed afforded the usual mineral and palæontological characters of the strata, the characteristic species being very abundant in some places. The lower lias at Jericho-wood consisted, in the upper part, of greyish clays passing into dark, slaty, and finely laminated clays, streaked with ferruginous bands and zones of small and large septaria; the fossils were not distributed throughout, but occurred in bands; among the most abundant were *Ammonites, Belemnites, Pecten, Inoceramus, Cardinia.*

Commencing south of Grantham, the first or Spittlegate Cutting is through the upper lias, consisting of about 30 feet of dark tenacious clays, with four zones of small and large septaria, generally of a tabular form, and dipping with the clays towards the south-east; the upper part of the lias is of a grey or light ash colour, resulting probably from atmospheric action; above this is about 9 feet of very fragmentary oolitic rock, sometimes ferruginous, and associated with siliceous sand; some portions were more solid, and appeared as if *in situ*, but generally the bedding was very irregular and disturbed; a few fossils only were noticed, chiefly *Pectines* and *Serpulæ*. The lias, however, was tolerably rich in fossils, especially in some places; among the most abundant were *Nucula ovum, Panopæa donaciformis* (many in vertical position), *Ammonites Walcottii, A. serpentinus*? The railway crosses the deep and narrow valley of the Witham, which flows over a continuation of the upper lias: in the excavations con-

nected with the works some interesting facts were disclosed, tending to the inference that this portion of the stratum was deposited under very quiescent conditions. The lias was finely laminated, and interstratified with it were thin, tabular, calcareo-siliceous layers or septaria, containing abundantly the *Posidonia Bronnii* (now first recorded as British), and perfectly regular zones of two or three species of *Ammonites* in every stage of growth, from the most minute (about the size of a pin's head) to their full-grown or usual size—indicating, as it were, a colony of these creatures which must have lived and died on the spot. *Aptychi* were associated with many of the *Ammonites*, and with them were examples of *Orbicula reflexa*, Sow.

Remains of insects and of fish were obtained from this portion of the deposit; a fact in accordance with their mode of occurrence in a similar position, as regards the upper lias of Dumbleton, Alderton, and Ilminster*.

Although the inferior ferruginous oolite is not visible in the next cutting to be described, its range, position, and thickness are fully indicated, in ascending from the river to the level of the railway, by the surface of the ground and the occurrence of springs at the line of its junction with the lias: the thickness may be estimated at about 30 feet, the upper part occurring a little below the level of the line.

The Little Ponton Cutting next follows, and in which, as briefly noticed in Part I. p. 318, the oolite rocks are much disturbed and fissured, the dislocated beds lying at great angles, in various directions and very irregular; besides which, a small fault is visible in the great sand-pipe in the cutting. At certain parts, however, the strata are tolerably parallel. The greatest depth of the cutting is about 50 feet, and consists of the following descending series:—

	feet.
Rubbly oolite, composed of rag and very comminuted shelly beds	
Compact shelly beds, thick-bedded, some pisolitic	15
A thin band of slaty clay—2 to 3 inches.	
Compact marly and shelly rock, with *Lucina, Pinna, Ostrea, Avicula, Trichites*, Corals	5
Marly oolitic rock, containing *Gervillia acuta*	$5\frac{1}{2}$
Compact marly rock, with few oolitic grains	1
Thin vein of clay—2 or 3 inches.	
Coarse-grained oolitic rock	6
Stratified grey sandy clay	$1\frac{1}{2}$
Marly oolite, full of small Pectens	$0\frac{1}{2}$
Compact marly and sandy rock, with *Gervillia acuta, Trigonia Phillipsi*	$3\frac{1}{2}$
Ferruginous sandy oolite, with shells in fragments	1

* From the first two localities, Mr. W. R. Binfield has kindly sent me, for comparison, specimens containing insects and the same species of Ammonites. See also Murchison's Geology of Cheltenham, 2nd edit. by Buckman and Strickland, p. 35; and Brodie's Fossil Insects, p. 55. The insect and fish remains of Ilminster are noticed in an interesting paper on the fossils of the Upper and Middle Lias of that locality, communicated by Mr. C. Moore to the Somerset Archæological and Natural History Society, 1853.

The strata of this cutting, with the exception of the upper portion, are presumed to represent the lowest portion of the white oolitic rocks of the district, or those which immediately overlie the brown or ferruginous rock before noticed, into which the lower sandy bed is considered to pass. These strata offer some peculiar characters in their fossil contents, as compared with other districts, which might lead us to infer a different relative position, and will be hereafter noticed.

The physical characters of these beds also vary over the district, as might be expected from their nature, so that it is difficult to allocate each individual stratum; but a general uniformity is observable; the stratified grey sandy clay is seen occurring about the same position in the quarries at Waltham, nine miles south-west of the railway. As a general rule, it may be observed that these lower beds have a greater amount of marl in their composition than the upper beds, and this character obtains over a large space: in these beds also is found a certain assemblage of Testacea, some of which also occur in the Inferior Oolite of Gloucestershire.

The upper portion, or rag beds, are more shelly and pisolitic in structure, sometimes thin-bedded, and frequently showing false bedding or oblique lamination; the inclination of the laminæ being about 30°, and having in many instances a south-easterly direction. In this series frequently occur thick beds of freestone; a good section of them is seen in the neighbouring quarries at Houghton Hill.

Between the Ponton Cuttings are two sections of limited depth, from 6 to 9 feet, consisting of the shelly pisolite with false bedding, and containing many small univalve shells, as *Cerithium*, *Nerinæa*, *Patella* (*P. rugosa*), and some small bivalves; the drift, as noticed at p. 318, covering a portion of one of them.

The Great Ponton Cutting differs in its general section from that at Little Ponton, in consisting mostly of the upper beds of the series; at the north end the strata are dislocated and disturbed, having the larger excavations filled with the brown sandy clay, &c., and the smaller ones with rubbly oolite and patches of drift; about the centre the beds are tolerably uniform in position, and continue with a gradual inclination to the southern end (fig. 1), where they are covered by a thick mass of the northern drift, the inclination appearing greater than it really is, from the rise of the railway line to the same point.

A slight fault is visible at the northern end, bringing down the shelly beds. The average thickness of the section is about 30 feet, and, about the middle of the cutting, it exhibits, in descending order—

	feet.
Rubbly oolite	5
Eight to ten beds of shelly oolite, in some parts soft oolite and very fossiliferous, with five zones of *Terebratula* and *Lima* in various stages of growth, with intervening shaly beds	15
A soft marl, containing Oysters in abundance at the north end, dividing and becoming thinner and finely laminated southwards—varying from 1 foot to 4 inches.	
Marly rock, with Corals, *Nerinæa*, *Turbo*; irregular	2
Coarse shelly oolites and freestones	15

The freestones are not continuous, and, with the associated shelly rags and overlying marl, are lost beneath the level of the line towards the south end, near to the point above where the mass of drift first appears, the intermediate space being occupied with the shelly beds and zones of *Terebratulæ*. Between the oolite, and partly separating it from the drift, is a ferruginous band and about 7 feet of sandy clay and shale, the remnants merely of a thicker series of strata hereafter described (fig. 1, 1, 2, 3).

In the following table are enumerated the shells which have been obtained from the upper shelly beds of this cutting; among the most abundant are *Pecten lens*, *Lucina despecta*, two or three species of *Arca*, *Opis*, *Tancredia*, *Astarte*, and also *Cerithium* and *Nerinæa*. Corals, Bryozoa, and Echinoderms were very rare.

TABLE I.—*List of the Testacea of the Upper Shelly Beds at Ponton, Lincolnshire; and their Distribution in the Great and Inferior Oolite of Yorkshire and Gloucestershire.*

	Yorkshire.		*Glo'stershire.*	
	Gr. O.	Inf. O.	Gr. O.	Inf. O.
Pterocera (Alaria) armata, *Lycett & Morris*	*		*	
Cerithium gemmatum, *Bean*	*			
—— limæforme, *Römer*			*	
—— Beanii, *Lycett & Morris*	*			
Nerinæa Voltzii, *Deslong.*			*	
—— funiculus, *Deslong.*			*	
†Phasianella Pontonis, *Lycett*, n. sp.				
—— cincta, *Phill.*	*			
—— Leymeriei, *D'Arch.*			*	
—— latiuscula, *Lycett & Morris*	*			
Acteonina glabra, *Phill.* sp.	*			
Cylindrites gradus, *Lycett*				*
†—— turriculatus, *Lycett*, n. sp.				
Natica adducta, *Phill.*	*			
—— Gomondii, *Lycett*		*		*
Rissoa obliquata, *Sow.*	*		*	
—— cancellata, *Morris & Lycett*			*	
Turbo Labadyei, *D'Arch.*			*	
—— elaboratus, *Bean*	*			
—— Phillipsii, *Lycett & Morris*	*			
†—— gemmatus, *Phill.*				*
Monodonta Lyelli, *D'Arch.*			*	
—— discoideum, *Lycett & Morris*			*	
Trochus monilitectus, *Phill.*	*		*	
—— spiratus, *D'Arch.*			*	
—— Acis, *D'Orb.* (Inf. O. France)				
—— Belus, *D'Orb.* (Gr. O. France)				
†—— ornatissimus, *D'Orb.* (Inf. O. Fr.), var.				
Pleurotomaria reticulata, ? *Deslong.*			*?	
Trochotoma extensa, *Lycett*			*	
Rimula clathrata, *Sow.*			*	*
Patella rugosa, *Sow.*			*	*
†Tancredia axiniformis, *Phill.* sp.		*	*	
†—— angulata, *Lycett*			?	

Table I. (continued).

	Yorkshire.		*Glo'stershire.*	
	Gr. O.	Inf. O.	Gr. O.	Inf. O.
Opis similis, *Sow.*			*	*
—— gibbosus, *Lycett*				*
Cypricardia Bathonica, *D'Orb.*	*		*	
†Cyprina nuciformis, *Lycett*				*
Astarte recondita, *Phill.* sp.	*			
—— minima, *Phill.*	*		*	
—— excavata, *Sow.* var.			*	*
Lucina despecta, *Phill.*	*		*	
Myoconcha crassa, *Sow.*			*	*
Trigonia pullus, *Sow.*			*	*
—— Moretonis, *Lycett & Morris*			*	
Arca Hirsonensis, *D'Arch.*			*	*
—— Prattii, *Morris & Lycett*	*		*	
—— Eudesi, *Morris & Lycett*			*	
—— pectinata, *Phill.*	*		*	
—— oblonga, *Goldf.*				*
—— æmula, *Phill.*	*			
—— cucullata, *Goldf.*			*	*
Unicardium depressum, *Phill.* sp.	*			
†Ceromya similis, *Lycett*				
Mytilus imbricatus, *Sow.*			*	
Lima duplicata, *Sow.*			*	
†—— Pontonis, *Lycett*				*
—— bellula, *Morris & Lycett*	*			*
Pteroperna costatula, *Deslong.*			*	
—— gibbosa, *Lycett*				*
—— pygmæa, *Dunk.*			*	
Avicula echinata, *Sow.*			*	
Hinnites abjectus, *Phill.*	*	*		
—— velatus, *Goldf.*			*	
Gryphæa mima, *Bean*	*			
Ostræa gregaria, *Sow.*	*		*	
—— sulcifera, *Phill.*	*			
Pecten lens, *Sow.*	*		*	
Terebratula maxillata, *Sow.*			*	

The rock from whence the majority of specimens were obtained was a soft pisolite, the shells being generally well preserved and rarely broken. Associated with them were rolled fragments of marly rock and casts of shells in a similar matrix (chiefly *Nerinæa* and *Cerithia*), much rolled and eroded, some of them being slightly incrusted with calcareous matter, apparently resembling a similar phænomenon of recent origin described by MM. Serres and Figuier as occurring in the Mediterranean, in the vicinity of Algiers.

The oolite rock dips towards the adjacent valley, and has been pierced about 60 feet in sinking a well close to the line of railway: it is also quarried in the vicinity.

† These species are described in the Appendix to this paper, and figured in Plate XIV.

The cuttings continue through the drift for four miles, as above described, Section 4, p. 320; the southern inclination of the line commencing about the north end of the long Drift section.

With the following section commences a new series of beds, the characters of which have not hitherto been fully noticed, and which, from their peculiar features and position between the Oolite and Cornbrash, are the equivalents of strata not heretofore recognized as occurring in this district. Two of the sections only, those of Essendine and Danes' Hill, show their full development; but the descriptions will be continued in regular order, so as to explain the variable nature of the strata, their thinning out, and the denudation to which they have been subjected.

South of the road from Colsterworth to Burton Coggles the section exposes in descending order the following beds:—

	feet.
Soft brown marly rock, with two intercalated layers of Oysters; the rock contains also *Perna quadrata, Modiola, Lima, Serpula*, &c.	6
Striped clays	2
Bituminous clay, with marine? shells: in this bed was found a large stem of a tree	$1\frac{1}{2}$
Grey clay, with nodules of limestone; and with vertical stems or roots of plants proceeding from the upper bed.	
Green and white clays	2
Slaty rock, shelly, containing *Ostrea* and *Cyrena*.	

The oolite occurs in the valley between this point and the section at Corby road, where it forms, for 7 feet, the lower part of the cutting; it consists of shelly oolite and freestone with false bedding, the inclination being 30° north. The oolite is covered, as is generally the case throughout the district where the upper clays extend, with a ferruginous band 1 foot thick, with occasional patches of selenite and Websterite?; over this are 15 feet of dark and greyish clays, with bands of more bituminous clay and lignite, but no traces of shells were observed. The clays and oolite continue through the next cutting, but the beds are less regular, the clays indenting the oolite, which is very rubbly where exposed, but at the base is fine-grained and occasionally shelly: the principal joints are N.W. and S.E.

The Swayfield Cutting presents a similar section to those just described, consisting of dark green and brown clays, wavy and irregular, overlying the oolite and the intervening ferruginous band; the oolite is shelly in places, contains marly concretions or pebbles, and is sometimes pinkish and fine-grained, at others coarsely pisolitic, and bluish in the centre of the mass. Over some parts of this, as well as the two preceding sections, traces of small angular flint and oolitic gravel were observed.

The Counthorpe Cutting is a continuation of the same series of beds, but increased in thickness and varying in character; in descending order:—

	feet.
Mottled clay with bands of Oysters	3
Dark bituminous clay	1
Compact sandy and occasionally soft shelly rock, with vertical remains of plants; the shells are not numerous, comprising the genera *Natica, Modiola, Trigonia*	3
Stratified dark green and brown shelly clays	4
Stratified dark clays with layers of shells, not broken, and indicating the beds to have been deposited under quiet conditions; the shells are *Avicula, Cytherea, Pecten, Lima, Ostrea, Terebratula, Lingula,* and probably *Cyrena*	4
Mottled and dark clays	6
Bituminous band	0½
Stiff brown and greyish clays: no shells: numerous vertical plant-markings	7
White and yellow clays	3
Ferruginous band	1
Oolite, fine-grained and pinkish, the blocks occasionally with blue centres *; some of the beds coarser, and containing small shells, as *Cerithium* and *Nerinæa,* from	12 to 13

Two small sections of the oolite occur between this and Creeton Cutting, which latter exhibits the following descending series:—

	feet.
Irregular laminated grey and green sands and clays, with layers full of shells in parts	6
Soft sandy rock full of shells, as *Modiola, Ostrea, Pecten*	1½
Bituminous and dark green clays, with occasional shelly layers	5
Greyish clays, in some parts finely bituminous (6 inches), at base	1½
Greenish sandy rock with vertical plant-markings	1½
Various-coloured clays, green, grey, brown, without shells	10
Ferruginous band	1
Oolitic rock, thick-bedded and horizontal, with occasional false-bedding at the upper part; inclination of oblique laminæ 30° N.	

The Little Bytham Cutting presents a similar section, the beds varying somewhat in character (*i. e.* less fossiliferous) and thickness, especially towards the upper part; the sandy rock with *Modiola* is wanting, but the clays are full of small Oysters and much thicker; the total thickness of clays is about 30 feet overlying the oolite †; the

* From some recent experiments it would appear that the blue colour of the oolite may be due to the presence of sulphuret of iron: see a paper by M. Ébelman, Bull. Géol. Soc. France, 2 ser. tom. ix. p. 221.

† The clays which here cover the oolite (and the observation applies to the whole district) have materially tended to its preservation as a solid rock, in preventing the ordinary effects of atmospheric action, which, when the surface is not so covered, causes it to split up into shivers and renders the upper part comparatively useless as a building material. This observation may be useful to those who have occasion to search for or avail themselves of the building-stone of the district.

latter was quarried to some depth below the level of the line and presented the following:—

	feet.
Pinkish oolitic rock, obliquely laminated (45°), the thicker layers being separated by seams of clay with crystallized gypsum	1
Oolitic rock	4
Compact oolite with fragments of shells	5
Compact marly rock with *Nerinæa* and *Lucina*	3
Compact oolitic rock, about	8

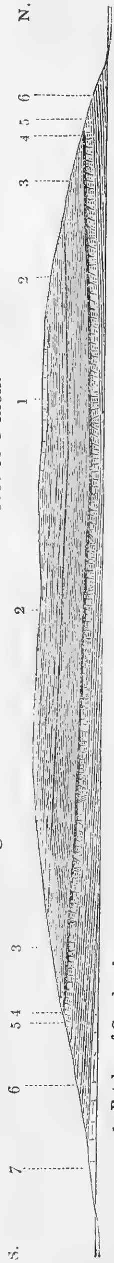
The Careby Cutting (denuded in the centre) extends for $\frac{3}{4}$ of a mile, and exposes the lower bituminous and brown clays overlying the oolite of 15 feet thickness; it is thick-bedded, and blue in its centre, sometimes obliquely laminated and shelly, with zones of marly concretions; the shells are chiefly *Lima*, *Pecten*, *Ostrea*, *Terebratula*, and a few corals; some of the beds exhibit a bored surface.

A small section again exposes the lower clays; and, crossing the valley traversed by the river Glen, Danes' Hill Cutting (fig. 3) exhibits a good typical section of the superincumbent clays, viz.—

	feet.
Cornbrash in patches, with the characteristic fossils	2 to 3
Compact sandy and marly rock	$3\frac{1}{2}$
Marly rock full of shells	2
Oyster-bed, compact at bottom and soft at top, full of oysters flatly arranged, and a few other shells, *Perna*, &c.	8
Clay and soft marly rock, very irregular	4
Clay enclosing shelly rock	4
Green sandy clay, *Pholadomya*, &c.	1
Bituminous clay	$0\frac{3}{4}$
Concretionary sand and lime rock	$0\frac{1}{2}$
Shelly clays, *Neæra*, &c.	$0\frac{1}{2}$
Black and green clays (no shells)	$1\frac{1}{4}$

Fig. 3.—Section of the Oolites at the Danes' Hill Cutting.

Length 22 chains. Vertical scale 120 feet to 1 inch.



1. Patches of Cornbrash.
2. Oyster bed and marly rock.
3. Green and brown clays with marine shells.
4. Bituminous band.
5. Stem or root bed, with marine shells.
6. Stratified sands and clays.
7. Upper part of Oolite (capped with a ferruginous band), visible only at the south end of the Cutting.

In this Cutting the beds dip towards the central part, where there are indications of a small fault.

	feet.
Shelly and sandy clays, bituminous at base and with fragments of plants horizontally disposed	$1\frac{1}{2}$
Grey sandy and marly rock, upper part (9 inches) less shelly than lower, with vertical plant-markings (root- or stem-bed)	2
Shaly clay	1
Bituminous clay	$1\frac{1}{4}$
Green clays	$3\frac{1}{2}$
Greyish and dark clays, finely laminated	4

At the southern end these lower clays are about 15 feet thick between the root-bed and the ferruginous band, upon which latter they repose, and below which the oolite extends a few yards only into this part of the cutting. It may be remarked, that the beds exhibit a synclinal dip towards the centre, at the angle of which a small fault is visible, giving to the position of the stem-bed in this section an irregularity, and somewhat affecting the parallelism of it in regard to the other sections.

The Aunby Cutting, the contour of which is very irregular, although not exposing so complete a series as the last, still presents some differences, more especially observable in the arrangement of the plant-bed, which in this section exhibits a different mode of accumulation, being here replaced by two distinct bituminous layers, each of which has its accompanying root-bed; the upper bituminous clay attaining the thickness of 2 feet, with lignite and impure coal; the lower is about 3 inches, and, with its accompanying root-bed, thins out towards the north end of the cutting. The following is the series about the middle of the cutting:—

	feet.
Grey and whitish clays, with markings of plants at base	9
Sandy and shelly clays	3
Dark clays	5
Green clays, finely laminated	2
Bituminous clays with lignite and coal	2
Grey sandy clay with vertical plant-markings	$1\frac{1}{2}$
Bituminous clay, 2 inches.	
Grey clay with stems	$2\frac{1}{2}$
White and grey clays	7
Ferruginous band	1

The oolite extends along the base of the cutting.

With the Essendine Cutting, now to be described, the argillaceous and shelly series terminate, as far at least as the Railway sections are concerned. In descending order, and with a view of rendering the peculiar characters and affinities of these beds more intelligible, the physical features and organic contents will be more fully detailed. Observing the same order of arrangement, we commence with the upper beds (1), which are full of Oysters, with occasional patches of *Serpulæ*, 3 to 5 ft.; the rock (2) immediately below the oyster-bed is sandy and marly, becoming occasionally very compact, calcareous,

and bluish, and sometimes shaly, from 10 to 12 ft.*; in the marly portion the fossils are very abundant, as

Cardium.	Lima interstincta.
Modiola imbricata.	Ostrea Bathonica.
Trigonia Moretonis.	Perna quadrata.
Cyprina.	Natica.
Unicardium varicosum (*Sow.* sp.).	Turbo tuberculatus.
Pholadomya lirata.	Phasianella cincta.
Terebratula maxillata.	Nautilus.
Pecten annulatus.	Acrosalenia hemicidaroides.
Lima cardioides.	

3. Green and irregularly sandy clays, fossiliferous, with layers of *Neæra* and *Pholadomya* abundant........	5 ft.
4. Marly, sandy and slaty rock, with *Avicula* and other shells	2
5. Dark green and bituminous, shelly clays, with *Cytherea, Neæra,* and *Cyrena*	4
Bituminous band	$0\frac{1}{2}$
6. Compact sandy and marly rock full of *Cardium, Cytherea, Neæra*	2
Variegated clays, bituminous, &c.; these beds contain a zone of dark clays, with *Cyrena Cunninghami, C.* (sp.?), and a species of *Mactra*	4

3. Thracia, abundant.	4. Avicula and Modiola, much compressed.	6. Cardium.
Modiola.	5. Neæra.	Modiola.
Pecten lens, rare.	Anomia.	Neæra.
Neæra Ibbetsoni.	Mactra.	Anomia.
Pholadomya acuticosta.	Cerithium.	Pinna.
Lingula.	Neæra.	Ostrea.
Terebratula obsoleta.		Astarte cuneata.
Anomia.		Cyprina.
Gryphæa nana.		

Some fine saurian remains, obtained from this cutting, were presented by Mr. Reynolds to the Museum of Practical Geology. Among these remains, which have been determined by Prof. Owen, were the tympanic bone of *Cetiosaurus longus,* the metatarsal bone of *Cet. brevis,* a fibula, and a fragment of a large vertebra.

The upper part of the Banthorpe Cutting (next in order) consists of about 7 to 9 feet of cornbrash rock, containing the characteristic fossils, and overlying a dark tenacious clay, sometimes laminated with shelly layers, below which, and forming the base of the line, is 7 feet of compact shelly bluish rock, occasionally sandy and becoming shaley, full of *Ostrea, Gervillia,* and *Avicula.*

In the Casewick Cutting the cornbrash, which is a grey, slightly compact and crystalline, shelly, and thin-bedded rock, occurs throughout the base of the cutting; its fossil contents are—

Pholadomya.	Pecten demissus.
Panopæa calceiformis, *Phil.* sp.	—— lens.
Modiola bipartita.	Terebratula Bentleyi.
Gervillia aviculoides, *Sow.*	—— obovata.
Goniomya litterata, *Sow.* sp.	Berenicea diluviana.
Lima rigida, *Sow.*	Serpula, two species.
Ostrea Marshii, *Sow.*	Portion of a jaw of Chimæra.

* The more solid portions of this bed have been recognized by Mr. Prestwich as being of frequent occurrence in the boulder-clay of Norfolk and Suffolk.

Resting upon this bed is the equivalent of the Oxford clay, consisting of 10 feet of dark laminated unctuous clay, with grey-brown sandy and ferruginous clay; the dark clay contained *Ammonites Herveyi* abundantly, as well as *Modiola bipartita, Trigonia clavellata, Thracia depressa, Nucula nuda*, Phil., and Saurian bones. The brown sandy clay, which passed into ferruginous rock, contained many well-preserved fossils, the most abundant being—

Gryphæa bilobata, in every stage of growth.
Belemnites Oweni or Puzosianus.
Ammonites Calloviensis, *Sow.*
Nautilus.
Pholadomya acuticosta, *Sow.*
Panopæa peregrina, *Phil.* sp.
Lima rigidula.
Avicula expansa, *Phil.*
Pecten demissus and P. lens?

These fossils would indicate that the ferruginous rock and grey sand were the equivalent of the Kelloway rock, which has not been previously noticed in this district.

Between this point and Peterborough the Cornbrash is exposed along the sides of the railway, covered in some places by thin layers of small gravel.

The facts disclosed in the above oolitic sections might at first sight appear of too limited a nature to warrant any general conclusions, were it not that they are intimately connected with and dependent upon the action of causes which have affected a wider area; more especially also as the peculiar physical features and organic contents exhibited by some of the strata, *i. e.* the argillaceous series, terminate in the surrounding district (as far at least as the observations of the author have enabled him to ascertain); which strata are likewise presumed to be the equivalent of beds in the upper sandstone and shales of Yorkshire, which have not been hitherto considered to range south of the Humber.

Before, however, proceeding further, it will be convenient to give a Table illustrative of what we consider to be the development of the lower oolitic series in Lincolnshire and the adjoining counties (Table II.), with a view of facilitating the comparison of them with the lower oolites of the North and South*; and also of explaining the beds exposed by railway sections; for it will only be by an attentive study of the features displayed by these deposits in the midland districts, that a correct or clearer knowledge will be obtained of their varying physical characters, and the changes that the area has undergone during their deposition.

* We here refer to the Coast of Yorkshire in the N., and the Counties of Wiltshire and Gloucestershire in the S.W.

TABLE II.—*Synoptical Table showing the relations of the Oolitic Rocks of the Southern, Midland, and Northern Districts of England.*

		S.W. of England.	Feet.	Cephalopods.	Lincolnshire.	Feet.	Cephalopods.	Yorkshire.	Feet.	Cephalopods.
Middle Oolite.		Oxford clay		abundant.	Oxford clay		abundant.	Oxford clay		abundant.
Lower Oolite.	Calcareous strata predominate.	Cornbrash		few.	Cornbrash	6	few.	Cornbrash		few.
		Hinton Sands, Forest marble	100	for the most part absent.	Marine clays and sands	15	for the most part absent.	Upper sandstone and shale	170	for the most part absent. Argillaceous and Arenaceous Strata.
		Bradford clay	40 to 60		Clays and shales, indicating terrestrial and fluvio-marine conditions	15		Limestone and shale	3	
		Great oolite	40 to 120		Shelly oolites, indicating littoral conditions. No *Myadæ*	20		Shale and sandstone	40	
		Fuller's Earth	0 to 130		Marly oolites, indicating deeper sea conditions and currents bringing terrestrial plants. With *Myadæ*, &c.	30		Limestone	10 to 20	
					Slaty beds, locally distributed. Collyweston and Kirby	10		Lower sandstone and shale	280	
					Sands, chiefly unfossiliferous, but containing plants. Ufford and Kingsthorpe	20				
		Inferior oolite	130 to 230	some.	Ferruginous oolite, with marine shells	20 to 50	very few.	Inferior oolite	80	very few.
		Lias		abundant.	Lias		abundant.	Lias		abundant.

To those geologists who are familiar with the Lower Oolites of the West of England, more especially as developed in the Cotteswold Hills, the above Lincolnshire section will appear somewhat anomalous, while on the other hand it will be readily perceived that in its main features it agrees with those of the Yorkshire coast and the North.

In a short paper communicated by Captain Ibbetson and the author to the British Association*, the affinities of the strata near Stamford with those of Yorkshire were briefly noticed, but a subsequent examination of another part of the district has enabled the author to confirm the opinion therein expressed, and to add many new facts, in which respect the Railway sections† above described have materially assisted, although there are still some anomalies to be cleared up, dependent on the distribution of the organic life of the period.

Commencing with the inferior oolite: this consists of a brown ferruginous sandy rock with little calcareous matter, and varies in thickness from 80 to 50 and 20 feet, and even less between the slate-beds and the lias near Collyweston; in the Witham valley near Grantham it was estimated about 30 feet; but few organic remains have been found through this district. Some of the beds, as near Wellingborough, have been used for the extraction of iron.

Above the ferruginous oolite, the Fuller's earth being here wanting, are beds of stratified sand and clays, local in their occurrence, and underlying the white oolite. These beds in some places, as at Ufford and near Kingsthorpe, show traces of bituminous clays from which proceed downwards vegetable markings, as if indicating terrestrial conditions. These beds, although of limited extent and occurring but locally *beneath the white oolite*, and where the slates are wanting, are of importance as indicating its superior position, and may therefore represent the lower sandstone of the Yorkshire coast, and the equivalent of the Fuller's earth of the south. The slate-beds, *i. e.* of Collyweston and Wettering, which also locally underlie the white oolite, were not met with in the railway cutting, but an equivalent bed was found reposing at the base of the series in the Little Ponton Cutting, and containing similar fossils to those found at Easton and Collyweston, such as *Trigonia Phillipsi, T. Moretonis, Gervillia acuta.* The beds, although locally developed, form part of, and pass up into

* Reports of the British Association, 1847, Trans. Sect. p. 127. This communication was the result of a survey of the oolitic quarries in the vicinity and south of Stamford by Capt. B. Ibbetson, accompanied by myself, in which some facts bearing on the present paper are given.

† The acknowledgement of much kind assistance during these investigations is due from the author to some friends, and to no one more than Mr. J. Bentley, of Stamford, who has verified with him the sections above given, as well as many others in the vicinity, and whose residence in the neighbourhood has enabled him to enrich our knowledge of the fossil fauna, but who is not responsible for any opinions herein expressed. Nor must it be forgotten how much the geologist has lost of a knowledge of this district by the non-publication of the observations made by Mr. Lonsdale during his elaborate survey, of which the coloured maps in the archives of the Society are full evidence.

the oolite above; but where the slaty character is wanting, the oolite reposes either on the subjacent sands or the ferruginous beds. The best points for their examination are near Kirby and Dene Park, Barnack, Easton, Collyweston, and Morcot.

[The most abundant fossils are the *Gervillia acuta*, Sow., *Trigonia Moretonis, Pecten personatus?*, a species of *Cardium*, and the *Pteroceras Bentleyi*, of the last of which beautiful specimens have been obtained by Miss Thompson, of Stamford. A fine species of *Astropecten* has recently been found in the slaty beds at Stamford by Mr. S. Sharp of that town. The *Lingula Beani*, Phil., occurs with *Pecopteris polypodioides*, in the same beds at Edith Weston.]

The importance of a clear understanding of the relative position of this slaty bed at the base of the white oolite series will be fully understood, when it is stated that a contrary opinion has been entertained and published, in which the *lower* marly series of the white oolite beds of this district are stated to be *inferior* to the slate-beds, and are arranged with the inferior oolite*.

Knowing the anomaly and feeling the difficulty of the subject, and admitting the existence of certain species in the lower marly series which are found in the inferior oolite of the West of England (more especially in the middle beds), as *Natica cincta*, Phil. = *N. Leckhamptonensis*, Lycett, *Pholadomya fidicula*, Sow., *Ceromya concentrica*, Sow. sp., *Nerinæa triplicata*, *N. longiuscula*, Bean, sp. = *N. cingenda*, Phil. not Sow., *Modiola plicata*, *Clypeus sinuatus*, and some others,—I have taken some pains to examine the locality, and have found some or other of these specimens *in situ* and above the slate-beds in many places, as near Morcot, Collyweston, Barnack, and Stamford†. These lower beds, which may generally be distinguished from the upper by the greater quantity of marl contained in them, form the chief part of the Little Ponton Cutting; these strata contain and are characterized by the occurrence of the Myadæ, as *Pholadomya*, *Panopæa*, and *Ceromya*, &c., with occasional zones of large branched

* See on this point a communication by the Rev. P. B. Brodie to the Cotteswolds Naturalists' Club.

† At Tinkler's Quarry and the adjoining lands near Stamford, a typical series of the whole district may be observed. In a higher part of the hill the stratified and bituminous clays, with the ferruginous band, may be observed overlying the freestones (Ketton and Casterton); the lower parts of the freestones form the top of the quarry: below which, compact oolitic rock, few shells, 2 feet: concretionary compact marly oolite, full of shells and zones of corals, 4 feet; the bottom more compact; the upper part marly, and decomposes more rapidly, containing shells in greater abundance: compact, hard, shelly oolitic rock, *Nerinæa*, &c., 2½ feet: compact oolitic rock, somewhat crystalline, 1½ foot: shaly bed, irregular laminated fragments of plants, and many compressed shells, *Lucina*, *Pecten*, &c., 2 feet: Stamford marble, very compact marly limestone, full of shells and corals, *Nerinæa* abundant, 2½ feet: indurated, somewhat marly rock, 3 feet: compact rock, 1½ foot: compact, marly, coarsely-grained oolitic rock, 2½ feet: fine-grained oolitic rock, 1 foot: cream-coloured marly rock, with *Nerinæa*, abundant, *Lima*, *Terebratula*, *Isocardia*, *Modiola*, *Lucina*, &c., 1½ foot: coarse oolitic rock, 2 to 26 feet: probably resting on the sands with slaty beds, which have been found in sinking lower down the hill, overlying the ferruginous rock which covers the upper lias.

and massive corals, and many specimens of *Nerinæa*. These lower marine beds frequently contain the remains of plants that must have been drifted from the neighbouring land. In the marly beds above the slates at Collyweston, the *Pecopteris polypodioides*, Brong., not Lindl., is of frequent occurrence; in a similar position at Tinkler's quarry near Stamford fronds of *Pterophyllum* are found, as also two species of the same genus at the Barnack quarries. In connection with these facts, it may be observed, that the Fern described by Lindley and Hutton* as obtained from the Wealden of Wansford, in Northamptonshire, belongs to the lower oolitic beds above the slates, and consequently the statement of the occurrence of the Wealden in that locality is erroneous. The upper beds or shelly rags of the Great Ponton Cutting, which are equivalent to the freestones of Ketton, Casterton, and Ancaster, and the shelly oolites of Barnack, vary from a coarse to a fine-grained structure, and contain in some places a fine and numerous suite of Testacea indicating somewhat an approach to littoral conditions. In the Ponton Cutting successive zones of *Terebratula* were accumulated, associated with a species of *Lima*; these portions of the rock are more crystalline than that in which the mass of species (before enumerated) were found. One marked feature in these oolitic beds is the almost entire absence of Cephalopoda; in all the collections formed in this district, I have seen but one or two specimens of *Ammonite* and *Belemnite*; their entire absence in the middle beds of the inferior oolite of the West of England is well known, and also the comparative rarity of them in the Great Oolite† of the South of England. In the Great Oolite of the Yorkshire coast about four species have been obtained.

The argillaceous strata which next succeed, and form so important a feature in the Railway cuttings, have been traced over a considerable area in this district. Their southern extension has been traced in some spots on the oolitic range which separates the Welland and the Nen, as at Weldon and the Woodpit near Wansford; at Ketton and the neighbourhood of Stamford they are fully developed, and they also cover in many places the oolite on each side of the railway, forming a part of the argillaceous lands of the county. In the district of the Drift they appear to cease, having been removed by denudation, and it is very rare to find a trace of them underlying that deposit. North of Grantham they occur at Ancaster and intervening spots towards Lincoln, where patches also are found.

* *Lonchopteris Mantelli*, Fossil Flora, t. 171. See also Mr. Lonsdale's note in Dr. Fitton's Memoir, Geol. Trans. 2 ser. vol. iv. p. 383*.

† Ten species are described in the Monograph of the Mollusca of the Great Oolite (Palæontographical Society): viz. five Ammonites, three Nautili, and two Belemnites.

Table III.—*Exhibiting the varying thickness of the Clays in the different sections.*

	Essendine.	*Aunby.*	*Danes' Hill.*	*Little Bytham.*	*Creeton.*	*Countthorpe or Swayfield.*
	ft.	ft.	ft.	ft.	ft.	ft.
Oyster-bed and marly rock...	11	0	16	8	16	5
Clays between the above and the stem-bed.	9	20	6	10		4
Stem-bed	$2\frac{1}{2}$	3	2	$\frac{1}{2}$	$1\frac{1}{2}$	5
Clays below stem-bed ...	4	7	15	$10\frac{1}{2}$	10	14
Iron-band	0	present	1	1	1	1
Oolitic rock	0	0	0	10	8	13

With the close of the deposition of the white oolitic rock, a new series of conditions set in, indicating a change from marine to, if not fluviatile, at least fluvio-marine action, the whole series of beds resulting from a very slow and gradual accumulation of sediment, as proved by the finely laminated appearance of many of the layers. Oscillations of the surface must, however, have taken place, as the bituminous bands infer a favourable condition for the growth of, perhaps, a marsh vegetation, the roots proceeding downwards amidst the recently elevated marine shelly mud, as seen in the continuous stem-bed of the sections. The bands of *Cyrena* were very local and confined to the lower portion of the series, being associated in some places with marine shells, as a species of *Mactra*. Marine conditions succeeded to the termination of the series, changes in the mineral matters occasionally taking place, and a partial different distribution of organic forms obtained, as seen in the layers containing numerous *Neæra*, *Pholadomya*, *Cytherea*, *Cardium*, &c., and scarcely any univalve testacea; above these beds again occurred an irregular muddy deposit, with numerous remains of testacea attaining a full size; amongst these are *Modiola*, *Cardium*, *Natica*. A zone of *Pholadomya* occurs in this part of the series, the shells occupying their normal position. A thick deposit of small Oysters, with a few other shells, terminated this succession of strata, above which the Cornbrash series began to be deposited.

We reserve for a future occasion the details of the data, obtained by traversing the intervening district, upon which we consider the synchronism of these marine and estuary beds of Lincolnshire with the Bradford clay and Forest marble of the South established: and, in considering them as the equivalents of the upper sandstone and shale of Yorkshire, it may be observed, that marine remains occur but rarely towards the close of the series in the latter area, the upper beds being almost entirely destitute of organic forms, i. e. *Testacea*. In a recent examination, however, of the coast of Yorkshire I found

a marine bed*, about 4 feet thick, intercalated with the upper series, but towards the lower part, and separated from the thicker mass of the Great Oolite by the fine plant-bed of Gristhorpe Bay, containing *Unio* and *Estheria*. In the strata above the marine bed, zones of bituminous clays can be traced with their associated root-bearing under-beds, similar to those above described in the Railway sections. That these strata are nearly synchronous with the estuary beds at Brora, described by Sir R. Murchison and by Mr. Robertson, and with those in the Isle of Skye described by Prof. E. Forbes, can scarcely admit of doubt, although in both the latter instances they appear to be intercalated between the mass of lower oolites and the Oxfordian series. Two species of *Cyrena*, however, described by Prof. E. Forbes are identical with species found at Essendine, and the allocation of genera is somewhat similar.

The above general observations tend to prove that considerable difference of mineral and organic character obtained in the Lincolnshire district, as compared with the south-west of England; the true Fuller's-earth rock of Mr. Smith not furnishing a constant or well-marked line of distinction between the Bath Oolite and the Inferior Oolite†, but being replaced by beds having conditions intermediate to and linked with those on the Yorkshire coast, long ago described by Professor Phillips. Instead of the two separate oolite deposits, Great Oolite and Inferior Oolite (as developed in the Cotteswolds), the Lincolnshire Oolite consists of one mass only (as in Yorkshire), between the Cornbrash and the ferruginous rock immediately overlying the Upper Lias shales, and blending in its fossil contents some of the conditions of the two oolites of the south-west of England.

In concluding this brief notice of the Lincolnshire sections, I must acknowledge my obligations to Mr. Reynolds and Mr. J. Cubitt for the use of the maps and working sections of this portion of the Great Northern Railway.

Description of some New Species of Mollusca *from the* Lincolnshire Oolites‡.

Lima Pontonis, Lycett. Pl. XIV. fig. 1*a*, 1*b*.

Testâ convexâ, obliquè ovatâ; auriculis parvis subæqualibus striatis; margine antico truncato excavato et striato; margine postico rotundo; costulis radiantibus numerosis (circa 60 ad 70) rotundis, interstitiis conformibus, densè et transversè striatis.

Shell convex, obliquely ovate, auricles small, nearly equal, and striated; anterior margin truncated, its slope excavated and striated;

* See also the paper by Mr. Williamson, Geol. Trans. 2nd Ser. vol. v. p. 324.
† Geology of Yorkshire, vol. i. p. 130.
‡ I am indebted to my friend Mr. Lycett for the examination and descriptions these species.

posterior border rounded; radiating costæ very numerous (about 60 or 70), rounded, with conformable densely striated insterstitial spaces.

The costæ are elevated, but very narrow and almost thread-like; the intervening spaces are transversely striated and are wider than the costæ; the height and opposite diameter are nearly equal.

In Gloucestershire this shell occurs in the middle division of the inferior oolite; its convexity and round elevated costæ, and the smaller height of the shell, will serve to distinguish it from *L. punctata*, which occurs with it in the Cotteswolds.

Locality.—Ponton, Lincolnshire.

Ceromya similis, Lycett. Pl. XIV. fig. 2.

Testâ ovato-oblongâ, convexâ; umbonibus magnis anticis curvatis; latere antico brevi convexo, postico elongato mediocriter attenuato; basi curvato; striis concentricis magnis regularibus et crebris.

Shell ovately oblong, convex; umbones prominent, anterior, and curved forwards; anterior side convex, short, its margin rounded; posterior side elongated, the superior border nearly horizontal, the shell becoming attenuated towards the posterior border; the lunule is excavated, the base curved; the sides of the valves have regular strongly impressed and closely arranged concentric striations.

The form of this species presents a near approximation to *Ceromya concentrica*, except that it is more elongated and oblique, the umbones more especially being more produced and having a much greater anterior curvature; the sides of the shell are also much more deeply marked by the striations than in *C. concentrica*. The form is really intermediate between that shell and *C. excentrica*, being less elongated than the latter species.

Height 15 lines; length 22 lines; diameter through both the valves 14 lines.

Locality.—Ponton, in the shelly beds; also in the lower strata of Stamford, Morcot, &c.

Cyprina nuciformis, Lycett. Pl. XIV. fig. 3.

Testâ subnuciformi, convexâ; umbonibus magnis curvatis; marginibus rotundis; latere postico angulo obtuso obliquo; lunulâ excavatâ.

Shell subcordiform or nut-shaped, convex; umbones large, prominent and curved forwards; margins of the valves rounded; posterior side with an oblique obtuse angle; lunule large, slightly excavated.

This species is distinguished from *Venus trapeziformis*, Rœmer, by the greater prominence of the umbones, by their less obliquity, and by the more globose figure of the shell: a Great Oolite Minchinhampton species is distinguished from it by a more compressed form and small umbones. In the Cotteswolds it occurs in the middle portion of the inferior oolite, where it is not uncommon: the height and length are about equal; the convexity of the valves is one-third less.

Locality.—Ponton, Lincolnshire.

Tancredia axiniformis, Phil. sp. Pl. XIV. fig. 4*a*, 4*b*.

Syn. Nucula axiniformis, *Phil. Geol. Yorksh.* i. t. 11. fig. 13.

Testâ ovato-elongatâ, aut subtrigonâ, umbonibus medianis acuminatis, parvis et depressis, latere postico angulo obliquo subacuto, margine ligamenti recto obliquo elongato.

Shell ovately elongated or subtrigonal, rather compressed; umbones mesial, depressed, but acuminated and small; posterior side with an oblique angle, which is rather acute, and separates a posterior space which is somewhat concave; hinge-margin straight, oblique, and elongated; anterior extremity of the shell pointed; posterior extremity slightly truncated.

This form is intermediate between *T. angulata* and *T. extensa*, Lycett. The external figure is nearly that of the latter shell, but the posterior angle in that species is much less prominent, and the space posterior to it, which is very narrow, is smaller, and has not the concavity of *T. axiniformis*; the general figure is also somewhat more convex than *T. extensa*.

Length 11 lines; height 6 lines.

Locality.—Ponton, Lincolnshire; also in the inferior oolite of Yorkshire and great oolite of Gloucestershire.

Tancredia angulata, Lycett. Pl. XIV. fig. 5.

Testâ ovato-subtrigonâ, umbonibus medianis acutis, latere antico compresso, postico angulum obliquum formante, margine cardinali brevi recto, basi curvato.

Shell ovately subtrigonal; umbones mesial, acute and prominent; anterior side compressed, its extremity pointed; posterior side with an oblique obtuse angle separating a flattened posterior portion; ligamental margin short and straight, basal margin with a considerable curvature.

This species is distinguished from *Tancredia curtansata* (*Corbula*, Phil.) by the more acuminated umbones and by the posterior angle; from the inferior oolite *T. donaciformis*, by the more prominent acute umbones and more lengthened form; the posterior aperture is only slightly indicated.

Height 9 lines; length 14 lines.

Locality.—Ponton.

Neæra Ibbetsoni, Morris. Pl. XIV. fig. 6.

Testâ subglobosâ, pyriformi, subæquivalvi, striatâ, umbonibus magnis submedianis, latere antico rotundo, postico producto brevi bicarinato, basi curvato, lateribus plicis regularibus inconspicuis, nucleo lævi.

Shell subglobose, pyriform, subequivalve, striated; umbones large, rounded, mesial; anterior side rounded; posterior side attenuated and produced, and bicarinated, the anterior carina sharp; lower margin curved; the sides with regular slightly impressed plications; nucleus smooth.

A very convex and nearly equivalve shell, with an acutely marked

angle upon the posterior produced slope, and with the anterior side short and rounded.

Height 9 lines; length 11 lines; diameter through both the valves 8 lines.

Localities.—Danes' Hill, Essendine, and the Ketton quarries.

This species is dedicated to Capt. L. B. Ibbetson, F.R.S., in whose company it was first noticed, much compressed in the clays above the Ketton oolite.

Turbo gemmatus, Lycett. Pl. XIV. fig. 7.

Testâ ovato-turbinatâ, spirâ elatâ, anfractibus (5) teretibus biangulatis, carinis tuberculosis tribus, anfractu ultimo magno, basi carinis numerosis parvis, aperturâ ovatâ, umbilico nullo.

Shell ovately turbinated, spire elevated, whorls (5) turreted, convex, biangulated, and ornamented with three tuberculated carinæ, of which the first carina is the smaller; the last whorl is large and ventricose; its base is convex and encircled with numerous small serrated carinæ; the aperture is ovate, its length being equal to two-fifths of the entire shell: no umbilicus.

The Lincolnshire specimens do not exceed five lines in length, but two specimens from the inferior oolite of Rodborough Hill near Stroud have a length of eleven lines, the diameter of the last whorl being seven lines. The presence of a third carina upon each whorl and the more ventricose form of the last will serve to distinguish it from *Turbo capitaneus*, Goldf., which in other respects it resembles. It is more slender than *Turbo ornatus*, Sow., and differs in the arrangement of the carinæ.

Localities.—Ponton, Lincolnshire; Rodborough Hill, Gloucestershire.

Cylindrites turriculatus, Lycett. Pl. XIV. fig. 8.

Testâ elongatâ, subcylindricâ; spirâ magnâ, acutâ; anfractibus (8) convexis; suturis profundè impressis; anfractu ultimo ovato; aperturâ angustâ.

Shell elongated, subcylindrical; spire lengthened, its apex acute; whorls (8) convex, their sutures deeply excavated, the last whorl ovately cylindrical; aperture narrow.

The figure of this species resembles *C. altus* from the great oolite of Minchinhampton, but the whorls are more numerous, and are not flattened as in that shell; the elevation of the spire readily distinguishes it from other contemporaneous species. The length of the aperture is about three-fifths of the entire shell.

Locality.—Ponton, Lincolnshire.

Phasianella Pontonis, Lycett. Pl. XIV. fig. 9.

Testâ turritâ, anfractibus convexis (6), spirâ elatâ, apice acuto, anfractu ultimo permagno ventricoso, aperturâ obliquâ, basi angusto.

Shell with the whorls (6) convex; spire elevated; apex acute; the last whorl very large and ventricose; aperture oblique; base narrow.

The superior size of the last whorl serves to distinguish it from

Phasianella paludiniformis, Buvignier, which in other respects it nearly resembles: the length of the aperture and spire are nearly equal.

Height 7 lines; diameter of the last whorl 4 lines.

Locality.—Ponton.

TROCHUS ORNATISSIMUS, d'Orb.? var. PONTONIS, Morris. PL. XIV. fig. 10.

Trochus ornatissimus, *d'Orb. Pal. Fr. Terr. Jur.* t. 312. f. 6–8.
?T. pileus, *Lycett, Ann. N. Hist.* 1850, p. 417.

Testâ subconicâ, umbilicatâ, anfractibus longitudinaliter costatis, costis (20) subacutis interstitiis transversim striatis, ultimo anfractu carinato, basi planulato vel subconvexo, concentricè semistriato.

A small but well-marked shell, rather wider than high, formed of few slightly concave volutions, having 15 to 20 acute and prominent longitudinal ridges, the interspaces marked with a few small costulæ; the base flat or but little convex, umbilicated, and the umbilicus surrounded by a few concentric striations, which do not extend to the outer margin.

This species belongs to a small section of the genus *Trochus*, of which but few allied forms are at present recorded in the Jurassic strata, viz. the *T. heliacus*, *T. lamellosus*, and *T. Tityrus* of d'Orb., and *T. pyramidatus*, Phillips. Our specimen, which is very imperfect, agrees with *T. ornatissimus*, d'Orb., but the base of that species is more convex.

Localities.—Ponton and Barnack.

M. d'Orbigny's specimen is from the inferior oolite of Calvados.

ASTARTE EXCAVATA, Sow. Var. COMPRESSIUSCULA, Morris.

Compared with the well-known Inferior Oolite shell, this variety presents some marked differences: it is more discoidal, the test more delicate: the fine, irregular, concentric striations but faintly represent the prominent large plications of the typical form: the dimensions are at least one-half less; and the greater number of specimens have still smaller proportions. The young examples of this variety, when only 3 or 4 lines in diameter, are equally distinguishable; they are very delicate and flattened, with three or four distinct plications near to the umbones, the remainder of the surface being nearly smooth. The ultimate stage of growth in our variety exhibits a greater thickness of test and convexity of form, therein approximating to the type; and, in fact, but for the inspection of this latter condition, it would be regarded as a distinct species. In the Cotteswolds and the West of England the *type* shell occurs in the lower division of the Inferior Oolite: the freestone beds of the middle division in Gloucestershire contain the variety *compressiuscula*; in the upper division of the Inferior Oolite the *type* reappears: again, in the Great Oolite of Minchinhampton the variety *compressiuscula* is abundant: the two varieties never occur together.

Dimensions of the largest specimens:—Height, 13 lines; length, 19 lines; diameter through both the valves, 3 lines.

EXPLANATION OF PLATE XIV.

Fig. 1. Lima Pontonis, *Lycett.*
Fig. 2. Ceromya similis, *Lycett.*
Fig. 3. Cyprina nuciformis, *Lycett.*
Fig. 4. Tancredia axiniformis, *Phillips*, sp.
Fig. 5. —— angulata, *Lycett.*
Fig. 6. Neæra Ibbetsoni, *Morris.*
Fig. 7. Turbo gemmatus, *Lycett.*
Fig. 8. Cylindrites turriculatus, *Lycett.*
Fig. 9. Phasianella Pontonis, *Lycett.*
Fig. 10. Trochus ornatissimus, *D'Orb.* Var. Pontonis, *Morris.*

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2. *On the* Insect Beds *in the* Purbeck Formation *of* Dorset *and* Wilts ; *and a Notice of the Occurrence of a* Neuropterous Insect *in the* Stonesfield Slate *of* Gloucestershire. By the Rev. P. B. Brodie, F.G.S.

[The publication of this paper is deferred.]

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3. *Description of the Remains of* Fossil Insects *from the* Purbeck Formation *of* Dorset *and* Wilts, *and from the* Stonesfield Slate *of* Gloucestershire. By J. O. Westwood, Esq.

(Communicated by the Rev. P. B. Brodie, F.G.S.)

[The publication of this paper is deferred.]

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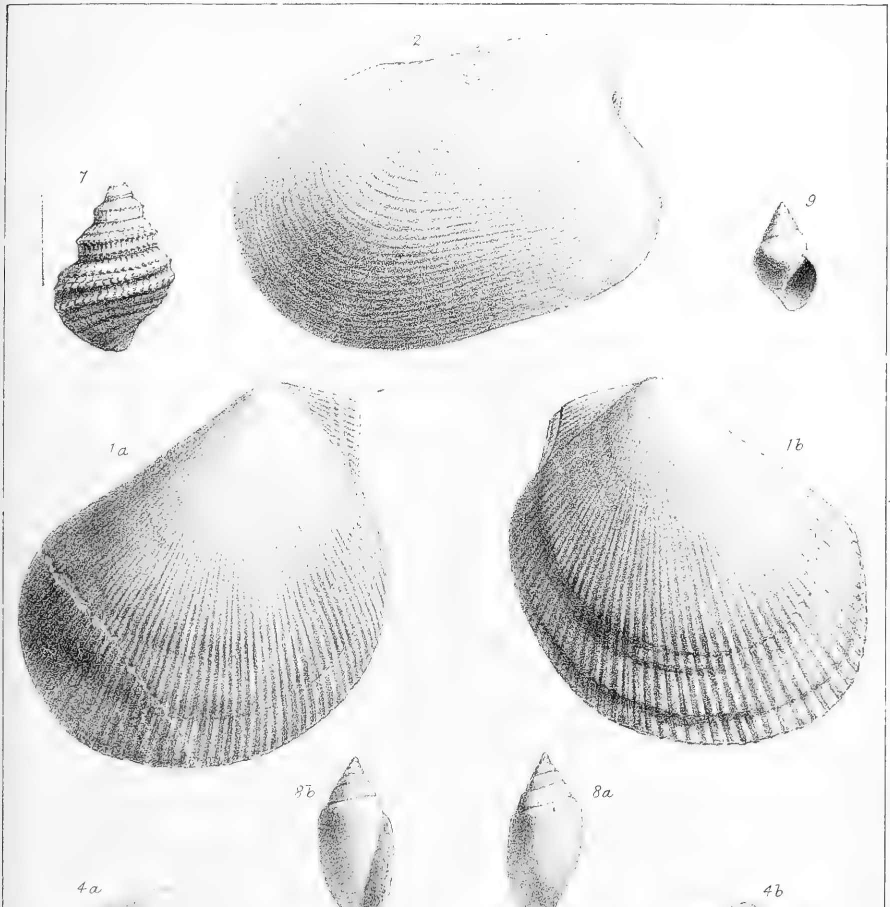
4. *On the* Microscopical Structure *of some* British Tertiary *and* Post-tertiary Freshwater Marls *and* Limestones. By H. C. Sorby, Esq. F.G.S.

[Abstract*.]

The author first described the general conclusions he had arrived at with respect to the condition of the mineral portion of calcareous organisms, which he considered is first deposited in the form of crystalline granules of variable size, that afterwards undergo more or less of crystalline coalescence. In some cases this scarcely occurs at all ; but in others it does to a very considerable extent during the life of the organism, and this produces a great difference in the character of the particles into which it is resolved by decay. The falling to powder that then takes place is the result of the oxidization and removal of the organic portion, and, if no crystalline coalescence had occurred, the shell or other body might be resolved into the very minute, ultimate, crystalline granules ; whereas, if much coalescence had taken place, it would break up into much larger ones, showing in many instances its minute organic structure.

* The entire paper is not printed, by desire of the author, who intends publishing a general account of the microscopical structure of British rocks, in a separate form, with very numerous illustrations.



C.R. Bone

Ford & West Imp.

SHELLS FROM THE LINCOLNSHIRE OOLITES.

The particular forms of the particles into which the Limnæans and Paludinæ, found so plentifully in many freshwater marls, are resolved by decay, were then described and shown to present such definite characters as to render it easy to distinguish them with certainty from most others at all likely to occur in them. Soft loose marls can of course be investigated by mixing the particles in water; but thin sections of harder limestones must be prepared, and the facts which may be learned from them are in many respects very superior, and from them the relative proportion of the various constituents may be determined with great accuracy, by carefully drawing their outline on strong even paper with a camera lucida, and afterwards cutting out the several portions and weighing them. This method the author terms "physical analysis." To fully describe all the necessary particulars would occupy too much space for this abstract; but, by attending to them, very great accuracy may be attained, and the true physical constitution of the specimen stated in a manner quite different from what could be ascertained by chemical analysis, which, for the purpose of these inquiries, is often greatly inferior, though often most valuable in addition.

Proceeding to the application of these methods of research to particular cases, some white, marly deposits found in some of the filled-up lakes of Holderness were described, and shown to be composed of such particles as result from the decay of *Bithinia tentaculata*, mixed with a small but variable proportion of such as are derived from decayed Limnæans. In confirmation of this it may be stated, that though no entire shells are found in them, yet numerous opercula of the *Bithinia* occur, which therefore appear to have been less prone to decay than the shells themselves. Other similar marls of post-tertiary age were also described, and shown to have resulted from the decay of similar shells in variable proportion.

The soft marly portions of the Isle of Wight tertiary freshwater limestone were stated to be of precisely the same nature as the above, being composed of such particles as result from the decay of Limnæans, in which term are included *Limnæus* and *Planorbis*. The examination of thin sections of the harder varieties of the same limestone also shows that they were derived from the same source, mixed with a variable, sometimes very large proportion of fragments of Charæ; but they have undergone more or less of crystalline consolidation. As examples of them, two physical analyses may be given of specimens from Binsted, which will also serve to show the character of such analyses.

1. A hard, marly-looking specimen, with numerous cavities due to the removal of the shelly matter of more or less entire Limnæans.

Empty cavities	16·3
Fragments of Limnæans	15·6
Fragments of Chara	11·0
Fine grains of decayed Limnæans and Chara	57·0
Peroxide of iron	·1
	100·0

2. A hard, even-grained specimen, with no entire or large fragments of shells visible to the naked eye.

Grains of Limnæan shell showing structure..	5·7	18·0
Ditto not showing ditto..................	12·3	
Crystallized fine granules of shell, &c.......		55·9
Quartz sand		13·5
Very fine sand and decomposed felspar		12·1
Peroxide of iron chiefly in the substance of shell fragments		·5
		100·0

In the above-described marls and limestones are found several curious bodies, but in no great proportion; and, on the whole, they may be said to be derived from the decay of the freshwater shells found in them, and not from the deposition of chalky mud, which has a totally different character, though the calcareous matter in the water, from which the shells procured it, may have been derived from the contiguous chalk. It is worthy of remark, that in these marls no *Diatomaceæ* are found, though they abound in the clays associated with some of them; but the examination of tufaceous travertins has furnished the author with evidence which proves that contact for a long period with carbonate of lime decomposes and destroys their siliceous coverings, and therefore they could hardly be expected to occur in such deposits as those under consideration.

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5. *On the* Geology *of part of the* Sooliman Range. By Dr. A. Fleming, E.I.C.

[In a Letter to Sir R. I. Murchison, F.R.S., F.G.S., Pres. R. Geogr. S.]

Camp Veehowa, Dera Ghazee Khan Frontier, eighty miles N. of latter, close under the Sooliman Range, and about thirty miles direct from the Tukht-i-Sooliman, March 29th, 1853.

With the exception of occasional patches of corn crop now in ear (March), the whole central district of the Derajat, between the cultivated belt, or Kuchee, along the Indus and the foot of the Sooliman Range, is a barren alluvial plain, thinly dotted with dwarf jungle bushes of wild caper and petoo (*Salvadora Persica*), and in some places covered with a thick crop of lana (a species of *Salsola*?), by burning large quantities of which the natives obtain a coarse kind of carbonate of soda (Sujee). This latter plant is only found on plains liable to be flooded *moderately*, and in which saline matter is abundant. Its present habitat supplies both the above conditions, for although the river inundation never reaches it, yet, whenever rain falls in the hills, hundreds of mountain torrents escape from the various ravines and passes, and for a time convert the whole country into a sheet of water, which is however drunk up by the thirsty soil long before it

reaches the Indus. As very little rain falls in the Derajat, the natives for agricultural purposes (wells being very scarce, and water found in them at from 100 to 150 feet deep) endeavour to detain the water in its onward course as long as possible, and for this means all the country is traversed by "bunds" or embankments parallel to the hills, inside which they plough the ground and sow their scanty crops. As but little rain falls even in the hills in the cold weather, the cold-weather or wheat crop is a very precarious one, and in a season of drought, such as this has been, almost a failure. The rain or hot-weather crop, consisting of millet, Indian corn, &c., is a much more successful one and of more importance. Water-power and population only are wanted to convert the whole district referred to into a rich corn-field, the saline matter it contains not being in such quantity as to be deleterious to wheat crops, if means of irrigation are available.

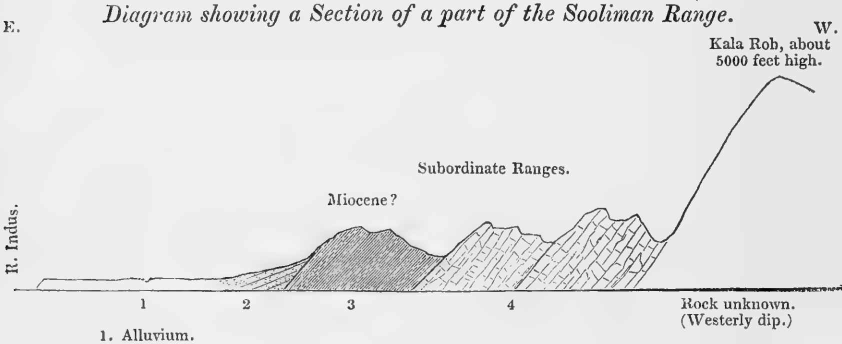
Separating the alluvial desert tract just noticed from the Sooliman Ranges is a belt of boulder deposit, varying in breadth from two to four miles: the boulders are larger and more numerous as we ascend towards the hills, on the strata of which they rest unconformably. The boulders occurring in this deposit appear to have been derived from the constituent rocks of the Soolimans. Some are of primitive or metamorphic rocks; but they chiefly consist of the sandstones and boulders forming conglomerates in the first or outer range of hills. These latter are of a character identical with the later Tertiary (Miocene?) or Sevalik strata of the Salt Range. They present in outline the same jagged character, and consist of alternations of sandstone (calcareous, and sometimes only indurated sand), calcareous grit, conglomerates, and indurated clays; and they everywhere present on their surface a saline efflorescence more or less distinct. In the outer range they dip at a very high angle to the E., and in some places are almost vertical. In the Mungrota or Sungurh Pass, into which on the 24th I made a short excursion, accompanied by troopers with loaded carbines, these miocene? strata occur on either side with an easterly dip for about two miles; the harder ridges of sandstone which cross the pass forming as fine natural defences as could anywhere be found; and indeed the Bosdar tribe who inhabit the hills at this point are by no means loath to use them as such, while covering the retreat of any of their brethren who may be returning from a foray in the plains.

On proceeding about two miles up the Sungurh Pass in a nearly west direction, the miocene? strata give place to beds of nummulite limestone, enclosing several species of Nummulite, and one very large species nearly an inch in diameter. Beds of this limestone alternate with dark bituminous clays, in which an *Ostrea* similar to one I got in the Salt Range is abundant, and under these a dark brown slaty calcareous sandstone, also containing numerous examples of a similar shell. Beneath this sandstone nummulite limestone again appeared, and *seemed* to form a second range, the strata of which dipped to the E. conformably at a similar and very high angle under the miocene? strata. Not deeming it safe to go beyond the nummulite limestone

range, and having reached about three miles inside the pass, I was obliged to return. I hope yet to have an opportunity of seeing what the inside of the Sooliman Range is made of, though I have no doubt it is merely a lower extension of the Salt Range (see Map, *supra*, p. 191).

The two outer ranges (for such they appear looking at them from the plain) are evidently portions of an anticlinal slope, the main or chief range (Kala Roh or Black Mountains as it is called) having a distinct *westerly* dip with a scarped face to the E. In several of the water-courses I have seen boulders of *Productus limestone*; and, as in several passes brine-streams occur and masses of gypsum of a most saliferous aspect, I feel assured the time will come when the Salt formation will be found. I cannot learn that salt ever has been found, though natives have told me that the red marl, similar to that which imbeds the salt in the Salt Range, does occur in the interior of the hills. The annexed rough sketch will make the structure of the

Diagram showing a Section of a part of the Sooliman Range.



1. Alluvium.
2. Boulder deposit.
3. Alternations of sand, sandstone, calcareous grit, conglomerates, and indurated clays.
4. { 1. Nummulite limestone alternating with dark bituminous clays with *Ostrea*.
   2. Dark brown slaty calcareous sandstone, with *Ostrea*.
   3. Nummulite limestone. }

range more distinct. As the Sooliman High Range* is of considerable height (pines are visible on it opposite to where I now am), it is most probable that in some of the passes which traverse it some most valuable sections are obtainable, and probably the formation on which the saliferous strata rest may be ascertained. Among the boulders in the pass I visited, I saw a sandstone which I believe belongs to the Saliferous series. The difficulties, however, in following out any researches in these hills are very great. One cannot go unarmed or without a party, and hence the explorer cannot follow the by-ways, but must keep to the highways. The Bosdars on the Dera Ghazee Khan Frontier, and the Kusranees and Shioranees on the Dera Ismael Khan Frontier, are all robbers and live by plunder, and would be only too glad to get hold of any of us, as we are here to cut them up if they appear on the plains intent on a foray.

* The Sooliman generally is destitute of trees and almost of brushwood; and its resemblance to the Salt Range is very great.

[On January 18, 1853, Dr. A. Fleming had the opportunity of riding up with an escort to the mouth of the Vidone Pass, opposite Dera Ghazee Khan. Here also he observed the deposits above noticed, and found boulders of white quartzite and of Productus-limestone.]

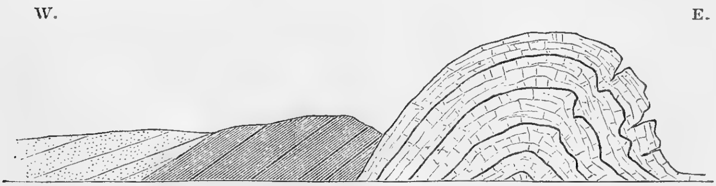
6. *On the* Geology *of a part of* Sind*. By H. B. E. Frere, Esq., Commissioner in Sind.

[In a letter to Col. Sykes, F.R.S., F.G.S.]

I have taken the opportunity of the "Duke of Argyll" going direct from Kuráchee to London, to send a couple of cases to your address. They contain a number of tertiary fossils, chiefly bones of Mammalia, very much resembling the Perim fossils; these were collected by Mr. Arthur Young, the Deputy Collector of Sehwán, who, if they are of any interest, would wish you to keep for your own collection any you like, and to present the rest, if you consider them worthy of presentation, to the India House, or any other public museum. Any account of what they are would be most acceptable, and any call for further information or more specimens would be carefully attended to. Neither he nor I have been able to reach the exact locality where they are found.

It is in the hills S.W. of the Munchur Lake and Sehwán, and about half-way to Sháh-billáwull, but on the E. side of the Hubb River. I must have been very near it in traversing the hill-route from Kuráchee to Sehwán in November 1851, but all the rocks I saw were nummulitic limestone greatly contorted, the ranges of hills being generally "wrinkles," as it were, of nummulitic strata; which could be for the most part traced with great clearness from the valley on one side over the hill and down into the valley on the other (see diagram).

Diagram showing the Section of Nummulitic Range between Kuráchee and Sehwán, in Sind, with the accompanying shale and gravel beds; as seen in the cross-valleys.



1. Beds of gravel and sandy conglomerate. } ? with bones.
2. Variegated marls and shales, or indurated mud-beds. }
3. Nummulitic limestone, forming the Range.

The western slopes of the ranges (the general direction of which is

* For Observations on the Geology of Sind, see Papers by Col. Sykes and Capt. Smee, Proc. and Trans. Geol. Soc. 1834; by Capt. Grant on Cutch, Proc. and Trans. Geol. Soc. 1847; by Capt. Vicary on the Beloochistan Hills, Quart. Journ. Geol. Soc. vol. ii. p. 260; and on other parts of Sind, ibid. vol. iii. p. 331.

N. and S.) were usually the least broken; but it was rarely difficult to trace the identical bed from valley to valley across the range, and for miles along the range. Though the strata were often not continuous, the dislocation of fragments was rarely so great as to prevent the original connection from being seen. The cross-valleys were generally not water-worn fissures, but huge cracks across the range, with the rocks on each side apparently little altered since they were rent apart. In one place a fissure of this kind gave a section of the range certainly not less than 1000 feet in depth; it was nummulitic limestone from top to bottom. The skirts of the hills and bottoms of the valleys parallel to the main ranges were often marked with alluvial deposits, conglomerates of nummulitic pebbles, and gravel, and I found in more than one spot, unmistakeable evidence of such valleys having been once lakes.

The only two good sections which I got of the strata in such situations, were, first near Meer Ahmed-khán-katánda, where a hot spring rose at the head of a small cross-valley in the nummulitic strata, which at that spot were nearly perpendicular. Upon these, less inclined, were beds of indurated mud and shale, and upon the skirts of the latter, down into the plain and across to the opposite range of hills, were beds of gravel and sandy conglomerate, at first inclined, but, away from the hills, gradually becoming nearly horizontal (see diagram, p. 349).

I suspect that the bones are found in a similar deposit, but my belief is founded only on the reports of the natives who found the bones. I failed to find any remains in either the gravel or shale, save one small splinter of bone in the gravel.

The other section was near Kujoor, where one of the cross-rents above-described cut right through a range of hills.

The indurated mud or shale is frequently of various brilliant colours, white, and all the shades of yellow, brown, and red which oxides of iron give. At the spots above-mentioned it was apparently resting on the nummulite rock, but more frequently it occurs where this rock is most dislocated, and appears to have been forced up from below. This is very frequently observable on the eastern slopes of the hills, which, as before observed, are usually more precipitous and broken than the western slopes. In two spots this eruption (?) of coloured marls and shales covers an area of several miles square. One is at Runnee-ke-kote or Mohun-kote, where the shale is sufficiently aluminous to afford alum for commercial purposes; the other is about eight miles from Sehwán. In both places, tables of nummulitic limestone are sometimes seen supported on the coloured marls, but in general the limestone has disappeared.

There are numerous unmistakeable traces of volcanic agency. Springs are rare, but what exist, generally at intervals of from ten to twenty miles, are usually hotter than the outer air; not exceeding, however, in any spring which I saw 109° F. Orifices, whence hot air and steam issue, are not uncommon; and in more than one spot, on nearly level plains, I found small eruptions of fused matter, forming mounds often not more than a few hundred yards in circumference.

Around the edge the blocks of nummulitic limestone (or conglomerate of pebbles of such rock) were hardly disjointed from the nearly level surface-stratum. Higher up the blocks became more dislocated and discoloured as by fire; a little higher they were more or less fused, and at the top of the heaps had often the appearance of vitrified slag.

The water of the warm springs in the Sehwán Hills has generally a trace of sulphate of lime; sometimes, indeed, is highly impregnated with it.

Some months ago I forwarded through the Bombay Secretariate a box of specimens of the sulphurous earth found in some localities near Kuráchee. It is not, I expect, pure enough to be worked economically.

On the Indus, March 19, 1853.

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7. *Further Account of the* BORING *at* KOTAH, DECCAN; *and a notice of an* ICHTHYOLITE *from that place.* By Dr. T. L. BELL, Surg. 3rd Nizam's Cavalry.

[Communicated by Col. Sykes, F.R.S., F.G.S.]

[Abstract.]

IN the August number of the Quarterly Journal of the Society for 1852 (vol. viii. p. 230) is an account of the boring lately made at Kotah *, in the Deccan, in the search for coal; and at page 272 of the seventh volume of the Journal is an account of the fossil fish (*Lepidotus Deccanensis*) from the bituminous shale met with in the boring. In the present communication Dr. Bell states that, on account of the washing in of the soil, it was found necessary to make a new bore. After taking precautionary measures, by constructing a wooden shaft through the alluvium, the boring was carried through the 27 feet of limestones, shales, &c. that were penetrated the previous year (1851), and a further depth of 64 feet 11 inches attained. This consisted of

	ft.	in.
Limestone	23	0
Blue clay	7	6
Limestone	2	0
Shale and clay	1	9
Limestone (more compact and crystalline)	1	8
Blue clay and shale	12	0
Red clay, penetrated to the depth of	17	0

* The position of Kotah is indicated at p. 272, vol. vii., but the following note gives it with greater definiteness:—Kotah is situated close to the confluence of the Godavery and what Arrowsmith, in the edition of his map in 1840, terms the Wandah, but which in this part of its course,—that is, just before its junction with the Godavery,—should properly be called the Pranheeta. Kotah is on the left bank of the river, and nearly in the same latitude with Chinnoor. [General Fraser, in Letter to Col. Sykes, F.G.S.] A Map of this district will be found in the Transact. Geol. Soc. 2nd ser. vol. v. part 3. pl. 46; and remarks on the limestone of the vicinity, *ibid.* p. 568.

An Ichthyolite having been found in a slab of limestone from the loose mass by the river side, noticed in Dr. Bell's former paper (Quart. Journ. Geol. Soc. vol. viii. p. 232), and which Dr. Bell regards as having been forced up by the action of the river, it has been forwarded to England by General Fraser; and Col. Sykes having submitted the specimen to Sir P. Egerton, he was favoured by Sir Philip with the following opinion respecting the character and relations of this Indian fossil fish:—

"It belongs to the section of the genus *Dapedius with single pointed teeth*;—*Tetragonolepis* of Agassiz—not of Bronn *. It appears to be a new species, differing from those hitherto described in the ornamental pattern of the scales. It is an Oolitic form, probably of the age of the Lias."

Col. Sykes proposes to name this second oolitic fish from the Deccan, DAPEDIUS EGERTONI.

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8. *On the* ERRATIC TERTIARIES *bordering the* PENINE CHAIN. PART II. By JOSHUA TRIMMER, Esq., F.G.S.

[For Part I. see Quart. Journ. Geol. Soc. vol. vii. p. 201.]

THE facts which will be described in this paper are adduced in illustration of two points to which I have adverted in former communications as general phænomena; namely, that the elevation, to which the boulder-clay of the Lower Erratics ascends, increases as it is traced from the coast into the interior; and that within areas which have been beneath the "erratic" sea considerable tracts occur from which its deposits have been so extensively removed, that their former existence is only proved by occasional small outliers, which may be easily overlooked.

In a paper on the Erratic Tertiaries bordering the Penine Chain from Congleton to Manchester, I have described the superposition of the sand of the upper erratics to the boulder-clay, in the neighbourhood of Congleton and Macclesfield, as well as the cessation of both at a certain height on Alderley Edge, where, however, their former presence is attested by an occasional boulder of transported rock on its summit.

Both cease in the same manner on the steep flanks of the Penine Chain, where the sandy soil might be supposed to be derived wholly from the subjacent grits of the Coal-measures, if a few erratic pebbles did not prove that some of the smaller particles of which it is composed must have been transported, as well as the coarser fragments. A valley, however, runs for about two miles into the chain in the direction of the ridge on which Sutton Church stands, and this valley is filled with boulder-clay, which at its eastern termination must be considerably higher than the junction of the Boulder-clay with the

* See Sir P. Egerton's Observations on the relations of *Dapedius* and *Tetragonolepis*, in his Palichthyologic Notes, No. 4, at page 274 of the present Number of the Journal.

sand of the Upper Erratics about Macclesfield and between that and Capesthorn. This point also appears to the eye to be higher than that at which both cease on Alderley Edge.

In making a traverse from Macclesfield to Buxton, the same absence of erratic deposits was observed on the ascent of the Penine Chain, at about the first mile from Macclesfield; but at two miles and a half, the road is mended with gravel, containing a profusion of erratic pebbles, derived from an adjoining pit, in which a bed of very coarse gravel is exposed, about 5 feet deep, much rolled, and containing numerous fragments of granite. This bed of gravel is situated on the summit-level of the Coal-measures, and at the head of a valley running into the chain from the low grounds on the west.

From this point to Buxton, over the Millstone grit and Carboniferous limestone, I saw no traces of either erratic boulders or gravel; neither were any observable along the road from Buxton to Leek, until the comparatively low ground, about three miles from Leek, was reached, where Boulder-clay again made its appearance.

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9. *On some* Fossil Brachiopods, *of the* Devonian Age, *from* China. By Thomas Davidson, Esq., F.G.S.

[Pl. XV.]

So little is known of Chinese fossils that every fresh discovery interests the palæontologist, and more especially when the species are identical with those peculiar to European geological horizons.

The existence of Devonian beds and fossils in the province of Yuennam, at about one hundred leagues north of Canton, was discovered some years ago by M. Itier, and a species of *Spirifer* and *Rhynchonella* from that locality have been described and figured by M. de Koninck*.

My attention was lately called by Messrs. Waterhouse and Woodward to a small collection of Chinese fossils recently presented to the British Museum by Mr. Hanbury, and which I was requested to examine and describe, being informed at the same time by the last-named gentleman, that they were all sent to him from China by W. Lockhart, Esq., of Shanghai.

For the shells (Spirifers, &c.) he gives the locality of Kwang-si, observing that coal is also met with there: "Kwang-si is quite in the south, and the Chinese name for these fossil shells is 'Shĭh-een.'

"The fossil crustaceans (*Gonoplax incisa,* Desmarest) I have received under the name of 'Shĭh-hae.' They are said by the Chinese to be from the province of Kwang-si. Cleyer gives Hai-nan as the locality (*Specimen Medicinæ Sinicæ,*—Medicamenta simplicia, No. 266).

* "Notice sur deux espèces de Brachiopodes du Terrain Paléozoique de la Chine," Bulletin de l'Académie Royale des Sciences, Lettres et Beaux Arts de Belgique, 1846, tome xiii. pt. 2. p. 415.

"The teeth are called 'Lung-che;' they are stated to be found in the provinces of Shen-si and Shan-si.

"All of these fossils are employed medicinally in China, and my specimens were purchased in a drug warehouse in Shanghai*."

With respect to the few mammalian remains, Mr. Waterhouse states them to consist of—

"An upper molar tooth, and a molar of the lower jaw (besides some fragments of molars) of a species of *Rhinoceros*.

"A series of molar teeth of both jaws, which agree perfectly with the molars of the *Hippotherium* of Germany and France.

"An upper molar tooth of an *Hippotherium*, which, being considerably larger than any of the molars of Hippotherium which we possess from Germany and France, might belong to a distinct species.

"A portion of an upper jaw, with the four posterior molars, of a small Ruminant, allied to the Sheep, but of smaller size.

"Molar teeth of two species of Stags.

"The molar tooth of a *Bear*, apparently the last of the right side of the lower jaw; it is fully as large as the corresponding tooth of the great Cave Bear (*Ursus spelæus*), but the crown is more simple in structure."

After having examined the collection of shells, I arrived at this conclusion; that the specimens belonged to eight Devonian species, seven of which are common to several European localities, among which we may mention Ferques and Néhou (France), Belgium, and the Eifel, but they are not found all existing together in any one of these localities. In external aspect they most resemble those from Ferques, in which locality, however, neither the *Cyrtia Murchisoniana* nor the *Rhynchonella Hanburii* have as yet been discovered. If to these we add the other two described by M. de Koninck, the total number of Chinese Devonian types now known will amount to ten species:—viz. 3 of *Spirifer*, 2 of *Rhynchonella*, 1 *Productus*, 1 *Crania*, 1 *Cornulites*, 1 *Spirorbis*, and 1 *Aulopora*.

The following descriptions and figures are from the series presented to the British Museum by Mr. Hanbury.

1. Spirifer disjunctus, Sowerby. Pl. XV. fig. 1–5.

Spirifera disjuncta, J. Sow. Geol. Trans. 2nd Series, vol. v. pl. 53. fig. 8, and pl. 54. figs. 12, 13 (1837).

Spirifer Verneuilii and *Sp. Archiaci*?, Murchison, Bull. de la Soc. Géol. de France, vol. xi. pl. 2 (1840).

Shell transverse, with a straight hinge-line exceeding the average width of the shell; beak more or less incurved; area broad, flat, or concave, divided by a triangular fissure partially closed by a pseudo-deltidium in two pieces; valves moderately convex or gibbous, with the cardinal angles forming wing-shaped projections. In the ventral or dental valve a mesial sinus of variable depth extends from the beak

* In the Chinese Collection exhibited at Hyde Park Corner, in 1847, I remember having observed several *Spirifers*, which most probably had been obtained from the same locality.

to the front, and corresponds with a broad fold in the other valve. Externally the shell is ornamented by from 55 to 70 small ribs radiating from the beak and umbo to the front and lateral margins, sometimes bifurcating on the mesial fold and sinus, but more rarely on the lateral portions of the valves: these ribs are likewise closely marked by numerous concentric lines of growth. Shell-structure impunctate.

Observations.—This appears to be by far the most common species at Kwang-si, where the shell attained 19 lines in width, 15 in length, and 12 in depth; and it presents so many varieties which insensibly connect the *Sp. Verneuilii* with the *S. Archiaci,* Murch., that I am disposed to consider the two should constitute one single type, whose most ancient name, according to Mr. D. Sharpe, would be that given by Mr. J. Sowerby in the Geol. Trans. The *Sp. disjunctus* is a very common Devonian fossil, occurring at Ferques, Tatimont, Chimay, Rhisnes near Namur, Golzines, Voroneje, &c. The mesial fold and sinus vary greatly in depth in different examples, and this has influenced the general shape of the valves, as may be seen from some of the most marked varieties among the Chinese examples, which I have figured in Pl. XV.

2. CYRTIA MURCHISONIANA, De Koninck, sp. PL. XV. fig. 6–9.

Spirifer Murchisonianus, De Koninck, MS.; mentioned by Viscount d'Archiac and M. de Verneuil, in their description of the Fossils of the Rhenish Provinces, Trans. Geol. Soc. 2nd Series, vol. vi. p. 394; figured, Geol. of Russia, vol. ii. pl. 4. f. 1 (1845).

Shell inequivalve, equilateral, longer than wide; hinge-line shorter than the width of the shell; beak more or less incurved; area triangular, slightly concave, and divided by a fissure completely covered by a deltidium in one piece, but exhibiting a small circular or oval foramen excavated at or near its extremity under the beak. The auricular expansions produced by the cardinal angles are small. In the ventral or dental valve a deep mesial sinus corresponds to a fold in the dorsal or socket valve. The external surface is ornamented by a number of small ribs radiating from the extremity of the beak and umbo to the margins, and numbering from 45 to 55 on each valve, many of these, especially on the mesial fold and sinus, being due to bifurcation or intercalation. Shell-structure impunctate.

Obs.—This species is common at Kwang-si, and in the Devonian beds of Chimay (Belgium), from which locality were derived M. de Koninck's original types. It varies much in its proportions, as may be seen from the following measurements taken from three Chinese examples:—

Depth	10,	width	$9\frac{1}{2}$,	depth	$8\frac{1}{2}$	lines.
—	11,	—	$9\frac{1}{2}$,	—	6	—
—	12,	—	11,	—	$8\frac{1}{2}$	—

M. de Koninck has seen these Chinese specimens, and pronounced them identical with the Belgian examples, but they seem to differ somewhat from those figured by M. de Verneuil, under that name,

in the 'Geology of Russia,' which do not exhibit the well-defined deltidium and foramen characteristic of the subgenus and species. M. de Koninck likewise informs me that in Belgium his *Sp. Murchisonianus* is always found in the Upper Devonian beds immediately under the carboniferous strata, and he believes this to be also the case in China; but that the species he has described from the province of Yuennam belongs to a bed rather lower down, viz. to the age of the Eifel.

3. Rhynchonella Hanburii, Davidson. Pl. XV. figs. 10, 11.

Shell irregularly triangular, inequivalve, wider than long; beak acute, but slightly produced, incurved, and leaving a very small space for the passage of the peduncle. *Socket* or *dorsal valve* most convex, presenting a regular convex curve from the umbo to the front, where the shell attains its greatest elevation. The valves are ornamented by from eleven to twelve large ribs, but which only extend over the frontal and lateral half of the shell; three of these form a more or less elevated mesial fold, and in the ventral valve two commonly occupy the sinus: besides these the whole external surface is furrowed by small radiating striæ. Shell-structure impunctate: dimensions taken from two specimens,—

Length $8\frac{1}{2}$, width $9\frac{1}{2}$, depth 8 lines.
— $8\frac{1}{2}$, — 9 — $5\frac{1}{2}$ —

Obs.—Four or five examples of this species have been sent from Kwang-si, all exactly agreeing in external character and presenting the same number of plaits. The occurrence of striæ and plaits on the same shell is common to many forms, especially among the oolitic and cretaceous species, but more rarely so among the hitherto discovered palæozoic forms. The *Rh. Hanburii* is distinguished from the *Rh. Schnurii* by its triangular shape; the Prussian species being more square and globose, and differing likewise in the number of its large plaits; but the same character of striation occurs in these two species, as well as in the *Rh. Wrightii* from the inferior oolite of Cheltenham. In the young state, as seen by fig. 11, none of the large subsequent plications can be traced.

4. Productus subaculeatus, Murchison. Pl. XV. fig. 12.

Productus subaculeatus, Murchison, Bulletin de la Soc. Géol. de France, vol. xi. pl. 2. fig. 9 (1840)*.
—— ——, De Koninck, Monog. du Genre Productus, p. 142. pl. 15. fig. 4.

Shell semicircular; ventral valve regularly convex, globose, with small auricular expansions; hinge-line straight, almost as wide as the shell; beak considerably incurved; dorsal valve regularly concave;

* Refer likewise to a very interesting paper on this species by M. Bouchard, published in the Annales des Sciences Nat. Paris, Sept. 1842. Some examples from Ferques have attained dimensions twice as great as those hitherto obtained from China.

external surface ornamented by a number of tubular spines irregularly distributed. Shell-structure punctated. Length 8, breadth $9\frac{1}{2}$ lines.

Obs.—This species is so well known that it does not require any lengthened description; it varies much in the convexity or concavity of its valves. Two specimens have been obtained at Kwang-si, exactly similar to those found in the Devonian beds of Ferques, of Belgium, Prussia, &c. According to Prof. King this shell would belong to his genus *Strophalosia*.

5. Crania obsoleta, Goldfuss. Pl. XV. fig. 13.

Crania obsoleta, Goldf. Petref. p. 297. tab. 163. f. 9.
Orbicula cimacensis, De Ryckholt (*Mélanges Paléontologiques*), Acad. Royale de Belgique, vol. xxiv. p. 92. pl. 4. f. 3, 4.

Shell almost circular, inequivalve, more or less irregular from its mode of attachment, which is by the entire surface and substance of its lower valve; upper valve patelliform, more or less convex, conical or somewhat depressed, with its apex central or subcentral. Surface smooth, interrupted only by a few lines or rugosities due to growth.

Obs.—This *Crania* is very abundant at Kwang-si, where it is found adhering to Spirifers, and is identically the same as that occurring at Ferques and Néhou in France, in the Eifel, and in many other Devonian localities; it seems to be the one described by Goldfuss under the name of *C. obsoleta*, and I am inclined to believe that the same species has been subsequently described by the Baron de Ryckholt under the name of *Orbicula cimacensis*, from that author stating that his examples were obtained in the Eifel and from Ferques (these last having been furnished by M. Bouchard); and since those found in both these localities, as well as in China, are identically the same, I must infer that all belong to one species, viz. the *C. obsoleta* of Goldfuss; but none of these present the "*stries rayonnantes*" described and figured by M. de Ryckholt, and I believe that the Belgian author has mistaken the accidental reproduction of the striæ peculiar to the object of attachment for striæ belonging to the ornamentation of the species.

6. Spirorbis omphalodes?, Goldfuss, sp. Pl. XV. fig. 14.

Serpula omphalodes (Goldfuss), Petref. vol. i. p. 225. pl. 67. f. 3.
Spirorbis Hœninghausi, Stein. Mém. Soc. Géol. de France, vol. i. p. 358.

Shell orbicular, convex, subspiral, of one coil only, and transversely wrinkled near the aperture. Diameter 1 line.

Obs.—This fossil is abundant in the Devonian localities of Kwang-si, Ferques, Gerolstein, &c., attached to Spirifers and other shells. M. de Verneuil also mentions the species from Lake Ilmen, Volkof, and Voroneje.

7. CORNULITES EPITHONIA?, Goldfuss, sp. PL. XV. fig. 15.

Serpula epithonia (Goldfuss), Petref. vol. i. p. 225. t. 67. f. 1.

Shell tapering, slender, attached by the whole length of its inferior surface; upper surface convex, transversely wrinkled. Length 6, width 1 line.

Obs.—This fossil is found at Kwang-si, attached to Spirifers; it likewise occurs at Bensberg, Ferques, &c.

8. AULOPORA TUBÆFORMIS, Goldfuss. PL. XV. fig. 16.

Aulopora tubæformis, Goldfuss, Petref. vol. i. p. 83. t. 29. f. 2 (1829).
—— ——, D'Archiac et De Verneuil, Memoir on the Fossils of the Rhenish Provinces, Trans. Geol. Soc. 2nd ser. vol. vi. p. 404.
—— ——, Michelin, Icon. Zool. p. 186. pl. 48. f. 4.

A slightly produced creeping Polypidom, adhering to shells or to other marine objects, and composed of a succession of trumpet-shaped, tapering, divaricated tubes, fixed by all their length, more elevated at their broadest extremity, which is perforated by a circular or ovular aperture; the gemmation takes place near the calyx, either on the same line as the parent cell, or laterally; the average length of each polypidom slightly exceeds 2 lines, and the greatest width near the calyx does not much surpass 1 line.

Obs.—I have referred the Kwang-si Polypidom to the *Aulopora tubæformis* of Goldfuss, a species very common in most Devonian localities, where it is found incrusting shells and corals. It is especially abundant in the Eifel, at Reffrath, Ferques, Néhou, &c.

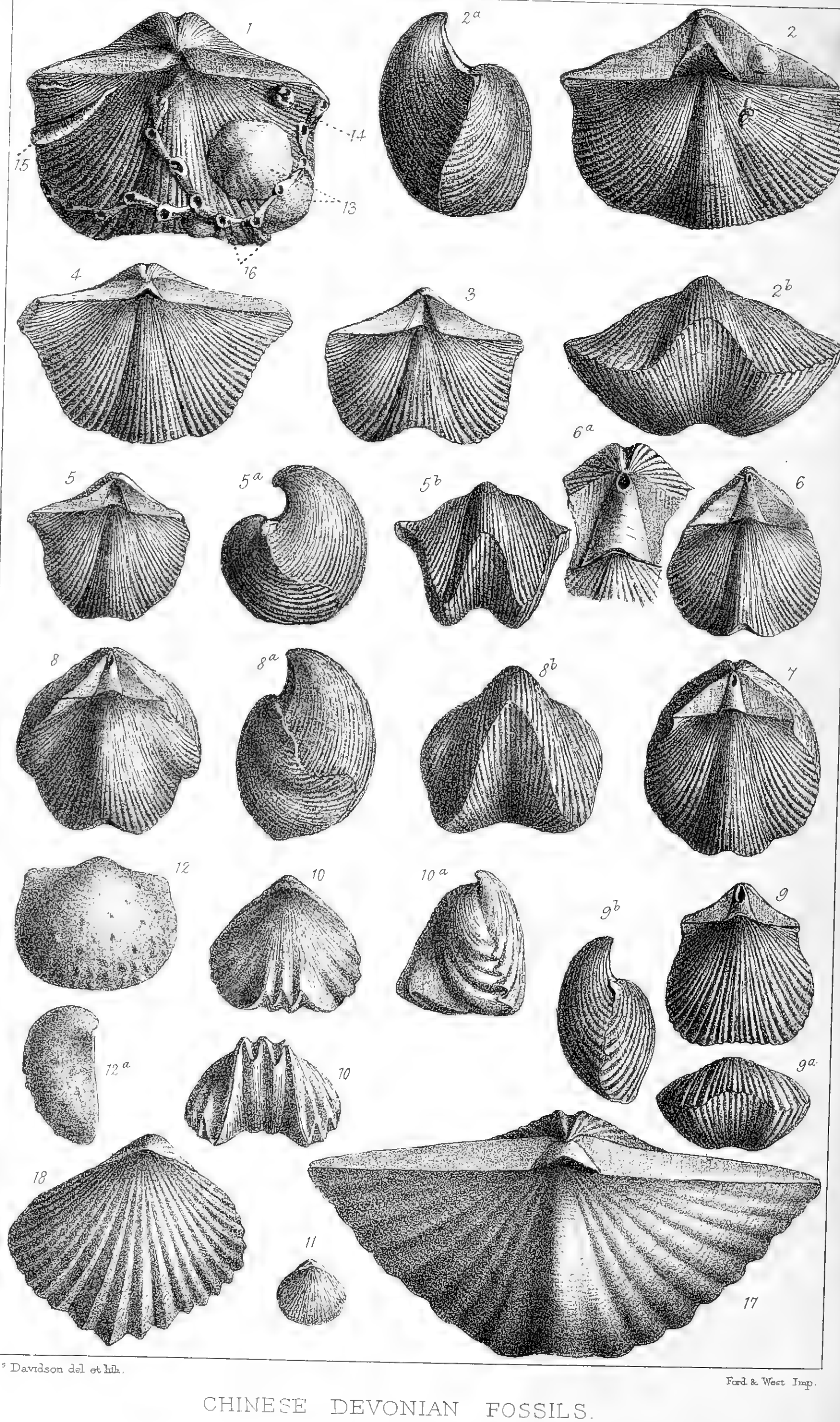
In order to complete and conclude this short account of the Devonian fossils from China at present known, I have added a brief description of the two Yuennam species, which will be found more amply described and illustrated in M. de Koninck's paper on the subject, and from which figures 17 and 18 are taken.

9. SPIRIFER CHEEHIEL, De Koninck. PL. XV. fig. 17.

Spirifer Cheehiel, De Koninck, Bulletin de l'Académie Royale des Sciences, Lettres et Beaux Arts de Belgique, 1846.

Shell transverse, subtriangular; hinge-line longer than the average width of the shell; beak small, moderately incurved; area narrow, slightly concave; the convexity of the shell is interrupted by a wide sinus in the dental or ventral valve, which corresponds to a mesial fold in the dorsal valve. Sixteen or seventeen rounded plaits ornament the surface of each valve; the sinus and mesial fold are without costæ. Length 16, width 33, depth 11 lines.

Found by M. Itier in a grey limestone in the province of Yuennam.



Thos Davidson del et lith.

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CHINESE DEVONIAN FOSSILS.

10. Rhynchonella Yuennamensis, De Koninck, sp. Pl. XV. fig. 18.

Terebratula Yuennamensis, De Koninck, Bull. de l'Acad. Royale de Belgique, 1846.

Shell rather broader than long, irregularly circular and globose. Dental valve more convex than the opposite one, with a short beak so much incurved as almost to touch the umbo of the socket-valve. Twenty-two to twenty-four radiating plaits ornament the surface of each valve. Length 13, width 15, depth 11 lines.

Found in the same locality as the preceding species, by M. Itier.

DESCRIPTION OF PLATE XV.

Figs. 1–5. Spirifer disjunctus, *Sowerby.*
Figs. 6–9. Cyrtia Murchisoniana, *De Koninck,* sp.
Figs. 10–11. Rhynchonella Hanburii, *Davidson.*
Fig. 12. Productus subaculeatus, *Murchison.*
Fig. 13. Crania obsoleta, *Goldfuss.*
Fig. 14. Spirorbis omphalodes, *Goldfuss?*
Fig. 15. Cornulites epithonia, *Goldfuss?*
Fig. 16. Aulopora tubæformis, *Goldfuss.*
Fig. 17. Spirifer Cheehiel, *De Koninck.*
Fig. 18. Rhynchonella Yuennamensis, *De Koninck,* sp.

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10. *On the* Caradoc Sandstone *of* Shropshire.

By J. W. Salter, Esq., F.G.S., and W. T. Aveline, Esq., F.G.S.

[The publication of this paper is deferred.]

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPER.

On the GRANITIC DISTRICT *of* INVERARY, ARGYLLSHIRE. By the DUKE OF ARGYLL, F.G.S.

[Read April 6, 1853*.]

THE whole area of the county of Argyll, with the exception of its islands and a mere strip along its outer coast-line, is occupied by the metamorphic rocks, with occasional masses of granite. On one portion of the mainland of the county, adjacent to the island of Mull, there is a large development of trap; and over the whole of the county there are to be seen frequent dykes of the same material, intersecting the strata in various directions.

But, with the exception of the localities already mentioned, I have seen no vestige, in any part of Argyllshire, of any of the palæozoic or secondary rocks. Nor is it probable that their absence is due to denudation, as in this case fragments would remain either amidst the masses of transported material, which are common on the surface, or —like the Old Red Sandstone along the external coast—preserved, *in situ*, among the intricacies of the hills. It would rather appear, therefore, that the mountainous district of this part of Scotland had already raised its head above the earliest seas which have yielded in their deposits the remains of life.

I need hardly say, therefore, that the geology of the county is wanting in that element which not only gives to geology the greatest interest as a study, but is the chief foundation of its certainty as a science.

When we have to deal with the Azoic rocks, nothing remains for us to elucidate but that which, as yet, is the obscurest branch of geology, I mean its mechanics;—a branch, however, on which we have every reason to hope that the science and researches of our late President will continue to cast new and important lights.

* For the account of this evening's Proceedings, *vide supra*, p. 134.

I venture to lay before the Society some observations upon the phænomena of a certain district in Argyllshire, with which, from residence, I am particularly acquainted, in the hope that they may possibly suggest some idea of the conditions or forces which seem to have determined the position, arrangement, and mineral character of the metamorphic strata as there developed.

The first feature in the general structure of the country, which is, I think, well worthy of notice, is one which belongs not only to the district I have just referred to, but, so far as I have been able to observe, to the whole county. It is the great spaces over which one uniform line of dip is preserved by the strata of the mica-slate; a dip which has no reference to any apparent intrusive rocks, but which, on the contrary, only changes where these rocks effect the alteration. The general strike-direction of the Argyllshire strata is that which is so prominently marked on the Map of Scotland by its deeply indented western coast, viz. from N.E. to S.W.; whilst the dip in one system of valleys is N.W., and in another S.E. Thus, on the Argyllshire shore of the basin of the Clyde, the mica-slates dip towards the S.E., this dip being exactly reversed on both sides of the great valley occupied by the waters of Loch Fyne. The block of intervening land in which this change takes place is happily intersected by a cross glen, which presents a magnificent section of the anticlinal ridge; ably and accurately described by Sir Roderick Impey Murchison in his paper communicated to the Society*.

This anticlinal has no aspect of being caused by any central mass of granite throwing off the strata in opposite directions. I do not merely mean that no such central mass makes itself *visible*, but that the regularity of the reverse dips, and the great extent longitudinally over which they are preserved, do not suggest any notion of a local upheaving action.

I now come to the special subject of this paper,—the structure of the next dividing block of land between two great valleys, viz. between Loch Fyne on the one side and Loch Awe upon the other; embracing what I have called the granitic district of Inverary. I am best acquainted with it, of course, in the immediate neighbourhood of Inverary, but sufficiently so throughout its entire length of some twelve or fifteen miles to feel pretty sure of the essential uniformity of its structure throughout.

I have already mentioned that the strata on *both* sides of Loch Fyne preserve the same north-western dip which they first assume halfway between the Clyde and Loch Fyne. This fact will at once be observed by the geologist who ascends that arm of the sea, and will account to him for some peculiar features in its scenery. Its bed being in the hollow between strata which dip at a high angle, but are conformable with each other and with the line of the Loch, one bank, of course, presents the escarpment, and the other the sloping side. Accordingly, along the upper reach of Loch Fyne, the right or more southern bank presents a steep but smooth and somewhat unbroken ridge, whilst the more northern bank has a much more

* Quart. Journ. Geol. Soc. vol. vii. pp. 168, 169.

varied and cliffy aspect; partly due to the escarpment side of the mica-slates, and partly to the frequent alternations of these with intrusive masses of a close-grained porphyritic granite.

It is the relative position which these two rocks occupy with reference to each other, and the manner in which they are associated, that constitutes the great peculiarity of this district.

We have seen that in the ridges between the Clyde and Loch Fyne, where there is a great anticlinal effected from some cause or another, there is no appearance of any intrusive rock; and we shall now find, that between Loch Fyne and Loch Awe, where there is a perfect conformity in the dip of the stratified slates, there the intrusive rocks are nevertheless developed in great force.

The summit ridge of this district (see fig. 1) is a ridge of mica-slate. It falls rapidly into the basin of Loch Awe, the dip of the strata being steeper along the line of greatest elevation, which runs far back from Loch Fyne, and much nearer to Loch Awe. The intervening space between this summit ridge and Loch Fyne is occupied by a series of lower ridges, in general diminishing in height as they approach the Loch. The *tops* of these ridges are granite; *but the tops only.* Both at their back and on their front, the stratified rocks ascend generally to more than half their height, as well as occupy the whole of the intervening hollows. In short, these granite tops may be said to be *interstratified* on a gigantic scale with the mica-slates; the latter always presenting the same dip and the same general direction. At many spots the line of junction is easily accessible; and the igneous and stratified rocks may be seen, surface to surface, in undisturbing contact with each other.

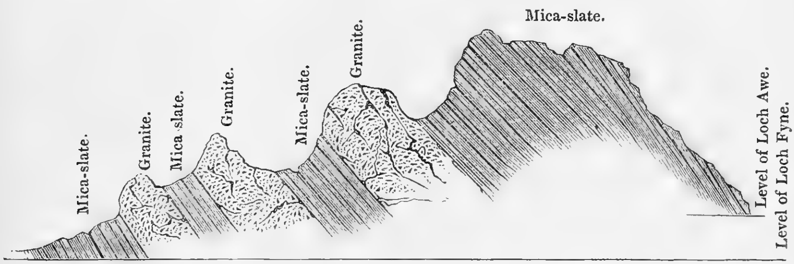
The general character of this peculiar association of the granite with the mica-slates will be best understood by an ideal section of the district (fig. 2).

Before venturing upon any suggestion

Fig. 1.—*Diagram-sketch of the Inverary District, as seen from Loch Fyne.* Length about 6 miles.

as to the possible cause of such an association of these two rocks, there is one preliminary question which must be either settled by proof, or passed over as not really admitting of any serious doubt; I mean the question of the sedimentary origin of the mica-slates. On this point I can only say, that there appears to me to be every proof except one—the remains of organic life. Nothing can be more complete and regular than the stratification of these rocks; and if there be any other mode whereby such a mechanical arrangement of earthy matter can be effected than that of aqueous deposition, it is a mode of which we have no knowledge. There are the same alternations,

Fig. 2.—*Ideal Section of the Inverary District.*



which prevail in all other sedimentary rocks, of siliceous, shaly, and calcareous beds; and in respect to the latter, I have had the benefit of examining some limestone strata in this district, along with Sir Roderick Murchison, which were pronounced by him to be not very much more crystalline than some of the limestones of the older rocks which are so abundant in their oceanic fossils.

The absence of organic remains, however, is of course no real stumbling-block in the way of our conclusion, as it is perfectly consistent with our knowledge of actual facts, that such remains, if they ever existed, may well have been obliterated by metamorphic action; and further, because it is equally consistent with theories having at least some probability, that in these very ancient rocks we should find evidences of a period anterior to the introduction of organized beings to our planet.

Taking for granted then the sedimentary origin of the mica-slates, and therefore the comparative horizontality of their first position, it becomes a question of much geological interest, how they came to assume such a highly inclined position, and how such masses of intrusive igneous rock came to be interposed between their beds, without interrupting their general conformability of dip and of direction; the igneous and the aqueous rocks assuming the position, as it were, of contemporaneous formations.

With igneous rocks of another class, this is no unknown phænomenon; sheets of trap or lava interposed between the beds of sedimentary rocks are not unfrequent; and a remarkable example has been brought under the notice of this Society by Professor E. Forbes, in reference to the oolites of Skye. But the cause of such a conjunction

is easy of explanation. Sheets of lava when once poured out are disconnected from the central source from which they came, and if so poured out on the bed of the sea, where strata are in the course of formation, and where similar strata continue to be formed after this event, there is no difficulty in seeing that they may preserve through all time and all changes, their original conformability with the rocks with which they are thus associated.

But can we reason in the same way in respect to masses of granite? Supposing them—which it is very difficult to do—to have been originally poured out upon the bed of the sea in which the slates were forming, what forces can have acted so equally upon thin crusts of sedimentary rock, and upon the deep-seated, deep-rooted hills of granite, that they should maintain through subsequent periods of great disturbance exactly the same relative position?

But, although I think such a supposition would at once appear in the highest degree improbable to any one who looks at the shapes and position of these great granitic masses, with due attention to what we know of the nature and origin of this kind of rock, as distinguished from lavas; there are some other circumstances which seem to me to offer decisive proof that such was not the mode in which the two rocks came to occupy their present relative position.

In the first place, we have clear evidence that the strata of the mica-slate *were not in the course of being deposited* when the granites rose; but that they *had already been consolidated* into hard and sharp fractured rocks, from the fact that fragments of these strata are found imbedded in the midst of the granite—caught up and involved in the melted mass. At a quarry of granite in the immediate vicinity of the town of Inverary, this is of very frequent occurrence; the fragments of slate being of various sizes; the granite fitting closely in to every angle of the broken edges.

Another decisive evidence of the posteriority of the granite to the complete consolidation of the mica-slates is supplied by a circumstance, of which, however, I have only seen one example; viz. a vein or string of granite running for a few feet across the bedding of the slates, at a point where the overlying strata are in close contact with the back of a granitic hill.

I take it, therefore, to be sufficiently proved, that the granite of this district is posterior to the mica-slates; and not only posterior to their deposition, but so immensely posterior, that the slates had already assumed very much the same mineral character which they have at the present day*. The question then comes to be, how such masses of intrusive rock can have effected that intrusion with so little disturbance to the conformability of the strata through which they rose?

One supposition is, I apprehend, at once excluded by the facts, viz. that the granites had burst up through the strata when they were still in a comparatively horizontal position, because in that case the intrusive force would have been exerted more or less nearly at

* At certain points the metamorphic strata seem to have been still further metamorphosed by contact with the granite.

right angles with the planes of stratification; and wherever such a force was exerted with success, those strata must have been violently broken and disturbed, as is so frequently the case elsewhere around the flanks of granitic hills.

To account for the phænomena which have been described, we must suppose the intrusive force to have acted under such conditions as regards the slates, that the planes of their stratification presented to that force the *lines of least resistance.*

No doubt there are conditions under which the planes of stratification would be also the planes of least resistance to liquid matter acting from below, although they had not lost their original horizontality,—conditions such as those already referred to, under which trap, rising through perpendicular fissures, is afterwards spread out laterally in sheets, either between, or on the top of, sedimentary strata. But I have already pointed out certain considerations which go far to show that such conditions are not applicable to the case before us; first, in respect of the difference between such sheets of trap and the irregular masses of granite; secondly, in respect of the difficulty of accounting in the latter case for the parallel position of the slates and granites being retained through changes during which the original horizontality was lost.

The situation of these rocks can be best explained, as it appears to me, if we adopt a supposition which it is the object of this paper to suggest to the Society, and which is also, I think, most reconcileable with the other phænomena of the district.

I account for the granitic masses occupying the position they now do in respect of the inclined strata of mica-slate, by supposing that the falling in of the mica-slates from an horizontal to an inclined position, and the rise of the granites along the loosened planes of stratification, were *connected* and *simultaneous* events. Such a falling in of the stratified rocks would have at once the effect of loosening the adhesion of their mutual surfaces, of causing them to slide off, open out, or otherwise separate from each other, and of forcing up the melted granites into which they fell. The present relative position of the sedimentary and igneous rocks, as if they were of contemporaneous origin, would be thus explained. Contemporaneous as regards *origin,* I have endeavoured to show they cannot be; but contemporaneous they really are, on the supposition above made, as regards their present relative position; inasmuch as the same movement which sunk the one, brought the other up to light.

It seems to me that one of the main features, not merely of the granitic district of Loch Fyneside, but, as before observed, of the greater part of the county, greatly tends to strengthen this supposition; I mean the prevalence of one direction of dip over extensive areas of country, pointing to some general cause operative over a wider field, and with greater equality of effect, than the mere local upheaval of eruptive rocks. Generally, where we have the uptilting of sedimentary rocks unequivocally due to such eruptions, we have evidence of repeated movements more or less of a local character, producing frequent changes of direction as well as of degrees of incli-

nation in the disturbed strata. In the mica-slates of a large part of Argyllshire we have regular anticlinal dips, ranging with remarkable equality and uniformity along considerable lines of country; we have *no* intrusive rocks where a section is afforded of an anticlinal ridge to the depth of some 1500 feet; and where we do meet with the intrusive rocks, we find them not *causing*, but themselves *conforming* to the dip.

I do not apprehend that he who makes such a suggestion can be legitimately called upon to go farther and account for the falling inwards of the mica-slates.

It is not the object of this paper to connect the local phænomena to which it refers with any general theory as to the origin of mountainous irregularities on the surface of the earth. The universal applicability of any one of these theories seems hardly consistent with the evidences of variety which mountainous districts present, as regards almost all the circumstances of their first and successive elevations. But, though there are many conceivable conditions under which the action of gravity might have produced such a falling in of the stratified crust from the withdrawal of internal support, it is impossible not to be struck by the explanation which the "shrinkage" theory of M. Elie de Beaumont and others would afford of the whole structure of this part of Scotland. The mineral character of the mica-slates has been long recognised as in all probability due to the metamorphic action of heat; and I have already shown that there are evidences of this mineral character having been fully acquired before the eruption of the granites. That it is not due to that eruption is farther evident from the fact of its prevalence and uniformity where no such rocks appear at all. It is not, therefore, an improbable supposition, considering the evidence which these rocks afford us, that they had been exposed to a very high temperature from some great general cause, widely operative over the surface of the planet; and if that heat were a decreasing one, shrinkage or contraction of the subterranean masses would inevitably result; which again would be followed by collapses inwards of the outer crust. At the time when these collapses apparently took place in the county of Argyll, the subterranean heat was still so near and so great, that the falling in of the strata to the depth of some 1500 or 2000 feet was sufficient, as we have seen, to force up along their surfaces great masses of granite, so little cooled as to be in a viscous, if not in an actually liquid state.

It would be a matter of much interest, if the crystalline rocks of the Highlands, which seem to belong to an age primæval even as regards the long æras of geology, should be found thus pointing to phænomena of a primæval character.

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PART II. MISCELLANEOUS.

CONTENTS OF PART II.

Alphabetically arranged—the names of the Authors in capital letters.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On some PALÆOZOIC FOSSILS *from the* CAPE OF GOOD HOPE. By DR. F. SANDBERGER.

[Leonhard u. Bronn's Neues Jahrbuch für Min. u. s. w., 1852, p. 581–585.]

IN 1836 the English naturalist Dr. A. Smith brought with him on his return from his travels in South Africa some fossils which were found in abundance in the Cedar Bergen, according to Captain Alexander * 150 English miles north of Cape Town and 2000 feet above the sea, in an ash-grey quartzose sandstone; and Murchison, in the 'Silurian System,' p. 653, enumerates the following species:—

Homalonotus Herschelii, *Murch.*
Calymene Blumenbachii, *Brongn.*
Cucullæa ovata, *Sow.*
Leptæna lata, *Sow.*
Orbicula rugata, *Sow.*
Nucula Smithii, *Sow.*
Turbo, sp.
Turritella, sp.
Conularia quadrisulcata, *Sow.*

On this he remarks that amongst these fossils there are some that are referable to the passage of the Old Red Sandstone into the Ludlow group, and others that are very abundant in the Ludlow and Wenlock groups; and he therefore regards the rock in which these fossils occur as Silurian.

D'Archiac and De Verneuil, in their "Memoir on the Fossils of the Older Deposits in the Rhenish Provinces †," add to the above the following species:—

Homalonotus Knightii, *Kœn.*
Calymene Tristani, *Brongn.*
Bellerophon acutus, *Sow.*
Spirifer macropterus, *Goldf.*
—— speciosus, *Schlth.*
Leptæna membranacea, *Phill.*

For the time when it was made this list contains nothing in itself contradictory, for the lower division of the Rhenish System (the Spi-

* Journal Royal Geograph. Soc. vol. viii. p. 3.
† Trans. Geol. Soc. 2nd Ser. vol. vi. p. 303 *et seq.*

rifer Sandstone, of which the *Spirifer macropterus* is the typical shell) was still reckoned as part of the Silurian System. Since that time, however, there is more and more proof that these beds should not be separated from the limestones and schists resting upon them, and that they have but very few species in common with the Silurian System, and those altogether of local occurrence; it was of much importance, therefore, to investigate the character of this fossiliferous rock of South Africa somewhat more closely. If indeed all these fossils really occur in one bed, there would be typical fossils of the Lower Silurian rocks (*Calymene Tristani*) occurring together with some of the Middle Silurian (*Calymene Blumenbachii*) and some of the lower part of the Rhenish System (*Spirifer macropterus*)—a circumstance altogether without analogy.

In 1842 Professor Krauss, of Stuttgard, made a report to the Naturalists' Association at Mayence on the fossils he had collected during his travels in South Africa, the scientific results of which are so valuable, especially in a geological point of view. The majority of these fossils belonged to the Lower Cretaceous Formation, only a few to the palæozoic rocks. These Lower Greensand fossils Prof. Krauss has since then fully described and figured*; of the palæozoic fossils, however, he has given no details. On account of the researches in the study of the palæozoic rocks and fossils of Nassau and their analogues in other countries, undertaken in company with my brother some years since, and some of the results of which have been laid before the public in "the systematic description and illustration of the fossils of the Rhenish System in Nassau†," I was induced to ask Prof. Krauss to communicate the palæozoic fossils which he had collected. He replied to my request in the most friendly manner, and at the same time supplied me with the following notes on the subject:—

"Unfortunately I cannot speak with certainty as to the locality of some, and indeed of the finest of the fossils, as they were not collected by myself, but given to me. I was informed that fine Trilobites were found in the Cedar Bergen, to the north of Cape Town, and at Kokman's [Cogman's] Kloof, in the Swellendam District. I was not on the western coast. That however Brachiopods also occur in the south-eastern part of the colony, is shown by specimen No. 45, from Kromme River, near Palmiet River, in the Swellendam District. Greywacke and clay-slate prevail throughout the plains and valleys of these districts, especially in Swellendam; whilst the mountain-ranges consist of variegated sandstone. In these plains are found Crinoidal joints. Limestone (No. 57) with schaalstein I found only in the Camgo Bergen, George District."

Of the localities here mentioned, the Cedar Bergen, to the west, and Plattenberg Bay, to the south-east of the Cape, lie about 120

* Nova Acta Acad. Cæs. Leopold. Carol. Nat. Cur. 1850, vol. xxii. part 2. p. 442 *et seq.* pl. 47–50. See also Quart. Journ. Geol. Soc. vol. vii. part 2. Miscell. p. 120 *et seq.*—[Transl.]

† Guido und Fridolin Sandberger's Systematischen Beschreibung und Abbildung der Versteinerungen des Rheinischen Schichten-Systems in Nassau; mit einer kurzgefassten Geognosie dieses Gebietes. Wiesbaden, 4to.

leagues apart, and the line connecting them is approximately the hypothenuse of a triangle enclosing the Districts of the Cape, Swellendam, and George. The palæozoic formation, therefore, forms probably the greatest portion of this part of the colony *.

The specimens that were given to Prof. Krauss, and to which he cannot assign a locality, consist of a brownish-grey, hard, fine-grained sandstone, sometimes softer [of a lighter colour?] from the presence of a yellow ochre. The latter closely resembles lithologically our Spirifer-sandstone of Pfaffendorf, Kemmanau, Buch, Holzappel, Manderbach, and that of the Kahleberg on the Hartz. The former is more like the unweathered sandy beds of Lahnstein and Braubach, and especially hand-specimens of the Oriskany sandstone from New York. The dark sandstone contains *Spirifer macropterus*, Goldfuss, var. *mucronatus*†, nobis, in great numbers, partly as casts, partly with the shell preserved, and sometimes above an inch in length. The yellowish sandstone, on the other hand, abounds with casts of *Chonetes sarcinulatus*, Schlth. sp. = *Leptæna lata*, Sow., and *Leptæna laticosta*, Conr., which are typical forms of the Lower Division of the Rhenish System. In one specimen we observed the very tumid cast of a Pelecypodous Mollusc; in another, *Tentaculites annulatus*. There are no traces of Trilobites.

Agreeing with the dark sandstone in lithological character is a specimen, marked No. 65, from Stofpad River, George District; this, however, contains only indeterminate casts of Bivalves, which certainly are not Spirifers. From the same locality, and also from Kromme River, are hand-specimens of yellowish or grey quartzose micaceous schist, underlying the series in which Brachiopods here and there occur; fossils, however, appear to be very rare, just as in rocks of similar lithological character with us. No. 46, from Pot River, Swellendam District, is a still more quartzose grey schistose rock, passing into sandstone; it contains no fossils, but a large cubic crystal of iron-pyrites converted into oxide of iron. A specimen marked "Plattenberg Bay, in the neighbourhood of Capt. Harker's Farm," is similar in general character; it has, however, a reddish-grey colour, and the schistose structure is more indistinct. No. 57 is a dark-grey fine-grained limestone, with a splintery fracture, here and there traversed with calc-spar: it altogether resembles many varieties of the Stringocephalus-limestones of Nassau, *ex. gr.* of Diez, Schuzbach, and Limburg. It appears to contain no fossils. In this rock is the famous Congo Cave, George District. From the Bosjesveld up to the Karroo Plains, in the valley of the Breede River, Swellendam District, the above-described schists exhibit a

* The extent of the East and West band of the palæozoic rocks here indicated is laid down in the Geological Map of South Africa accompanying Mr. Bain's paper on the Geology of the Cape, read before the Society Nov. 17, 1852, but not yet published. The Abstract of this Paper in the 'Literary Gazette' of Dec. 18, 1852 (No. 1874, p. 932), gives a general view of the distribution of the fossiliferous and unfossiliferous rocks of this portion of Africa.—[Transl.]

† Detailed description and figures of this interesting variety will be given in our large work above referred to.

great number of Crinoidal joints of most peculiar form and a well-preserved new species of *Terebratula*, allied to *Terebratula Livonica*, v. Buch, all changed into oxide of iron, which has, without doubt, been formed from iron-pyrites.

The fossils communicated by Prof. Krauss, although few in number, comprise three of the most important that are recognized in both hemispheres as typical forms of the Lowest Division of the Rhenish System. *Tentaculites annulatus* occurs both in this and in the Silurian System. The new species of *Terebratula* is as yet peculiar to the Cape, and of no use for the determination of the age of these rocks. With regard to the species quoted by Murchison, D'Archiac, and De Verneuil—*Nucula Smithii* is peculiar to the Cape; *Homalonotus Herschelii* is as yet known in Europe only in the Spirifer-sandstone; *Homalonotus crassicauda* (=*H. Knightii*, Kœn.) occurs in the Spirifer-sandstone and the uppermost Silurian (Ludlow) beds; *Bellerophon acutus* is found in England in the Caradoc sandstone, but also, and not unfrequently, in our Spirifer-sandstone; *Conularia quadrisulcata* included at the time the list was made a whole series of species from different beds, nor can it serve for the determination of the system before it is ascertained to which species the Cape specimen really belongs; *Cucullæa ovata* in all probability is not a well-determined fossil; and there remain as decidedly Silurian fossils only *Calymene Blumenbachii* and *C. Tristani*. *C. Blumenbachii* has been quoted by different authors too hastily as occurring in the Nassau Spirifer-sandstone; careful investigations tend to prove that imperfect specimens of the head of *Phacops laciniatus* have been referred to this species. Other Rhenish species of *Phacops* also have been confounded with *C. Tristani*; nor does the genus *Calymene* occur anywhere in the Rhenish System.

These two forms, therefore, if Murchison's determination be correct, would represent some Silurian rock. The rest of the fossils, however, afford no evidence in support of this, but, on the contrary, the three typical fossils of the Rhenish System, that are above referred to, show, without doubt, that these palæozoic beds of the Cape for the most part belong to the Spirifer-sandstone of the Rhenish System. [T. R. J.]

On LIMESTONES *in the* GNEISS *and* SLATE *of* NORWAY.
By TH. SCHEERER, of Freiburg.

[Zeitschrift der deutsch. geol. Gesellschaft. 1852, 4 Band, 1 Heft, p. 31–46.]

THE interesting results which Prof. Delesse has arrived at by geognostical and mineralogical examinations of the crystalline limestones in the gneiss of Vosges* are an inducement for us to institute a comparison of these with analogous phænomena in other countries. To draw such a parallel in the case of the limestones of Norway is to me the more interesting and important, as it is the fulfilment of a wish expressed by M. Delesse in a letter to myself.

* See Annales des Mines, tome xx. p. 141, &c.

The most important part of M. Delesse's observations is necessarily the history of the origin and local disposition of the accessory (or rather non-accessory) minerals, the presence of which is in the first place owing to the contact of the gneiss and the limestone*. Gneiss and limestone (regarded merely as chemical bodies, not with respect to their lithological character) have once, it appears, existed without the minerals at present included within them; and a series of geological events, accompanied by chemical action, has developed the latter within them, and more or less out of them. Both rocks, as they are now presented to us with their included foreign minerals, represent the last stage only of a series of geological and chemical operations, whilst the other stages belong to earlier epochs in the history of their formation, and as far as we are concerned are lost. The investigation of the *whole* series of phænomena would be frustrated by an attempt at a too particular enumeration of the several stages, unless we call Analogy to our aid, by which our conclusions may be pushed into apparently inaccessible regions. In applying this to the case before us, we shall have to direct our attention to the limestone occurring under similar conditions in later formations, and not confine ourselves to the consideration of the limestone in the gneiss; and this especially holds good with respect to the Norwegian phænomena.

Since I am to act as guide in this geological excursion, I must premise, that, from the length of time since my visit to Norway, many things have escaped me that may have been of importance for our purpose, and that the deficiency is only partially repaired by memoranda from my old note-books.

To some it may appear superfluous to carry on inquiries still further on the origin of crystalline limestones and the rocks in which they are included, as so many distinguished naturalists have already given us the result of their observations on this subject. Still it appears to me judicious, from a non-neptunian point of view, to make advances against ultra-neptunism, lately again rampant.

If we take a glance at Keilhau's map of the transition district of Christiania†, we shall see that fossiliferous clay-slate is the chief member of the stratified deposits here, for the most part conformable, and traversed by numerous bands of limestone. The chief feature observable here, viz. the sporadic occurrence of a limestone formation subordinate to the clay-slate, is still more plainly seen if we study the phænomena from place to place in detail. In nearly every hand-specimen of the Christiania clay-slate a more or less considerable quantity of carbonate of lime‡ is observable. Limestone beds, of the thickness of a few inches and upwards, alternate with clay-slate beds, the latter generally of greater thickness. The smaller of these lime-

* With regard to the local distribution of these minerals, conditions presenting so many interesting details and therefore not to be treated of in a mere sketch, I must for the most part refer to M. Delesse's original memoirs in the 'Annales des Mines.'

† Gæa Norvegica, Heft 1.

‡ Usually mixed with some carbonate of magnesia. Carbonate of iron is also present.

stones frequently do not form uninterrupted beds, but on the bedding-surfaces have the appearance of numerous and irregularly interrupted stripes running parallel to the dip of the strata, if the latter are inclined or bent. The component parts of these stripes consist of the bisected surfaces of very differently shaped calcareous nodules. There are places where these nodules occur in such quantities side by side and over one another, that one can almost believe he has before his eyes a limestone-conglomerate of which the clay-slate forms the matrix or cement. This, however, would be an erroneous view of the case, as is evident from the perfect gradation apparent in the condition of these rocks, passing from the thickest strata of fossiliferous limestone, through the thinner but still uninterrupted calcareous beds, to the interrupted layers of the same, and from these again to those resembling conglomerate.

From the consideration of the joint occurrence of the clay-slate and limestone in the Christiania territory, it results, with regard to the probable history of their origin, that, as chemical masses, both rocks were for the most part conjointly deposited during the same geological period,—that certain circumstances brought about the local predominance of one or other of these masses,—and that, lastly, the limestone beds, at least the smaller layers, were exposed to the influences that produced a more complete separation and segregation of the carbonate of lime, resulting in the formation of the nodular bodies. No new chemical products were thus generated, if we except some iron pyrites and calc-spar, the former of which is sprinkled here and there and even occurs in small nodules, and the latter is sometimes met with in the state of thin crusts. It is, however, quite evident that nowhere along the lines of demarcation have there been formed any bodies as the result of the contact of the clay-slate and limestone.

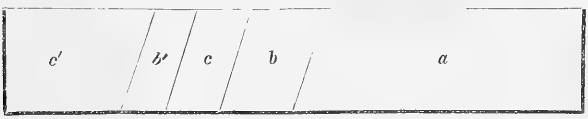
Let us now study this geological area at its line of junction with the granite. About six miles * south-west of Christiania, not far from the palace of Gjellebäk †, granite appears; and here, at more than one spot, we meet with a very favourable opportunity of becoming acquainted with the behaviour of the peaceable fossiliferous Transition strata towards their once so unquiet neighbour. But we must first observe, that near Gjellebäk the calcareous rocks play a much less subordinate part than at many other places in the territory of Christiania. We here meet with some large calcareous beds which on the Paradies-Bakken run up more or less closely to the granite; and here the latter cuts the strata nearly at right angles to their strike. South-east of Gjellebäk, on the contrary, from the Kjenner mines to the Ulve Vand, the strike of the beds for the most part runs parallel to the edge of the granite, and at the same time the limestone is here far less prevalent, and indeed in some instances quite subordinate.

The Limestone, Clay-slate, and Granite of the Paradies-Bakken.—We do not find here the thick limestone of Christiania, but a granular, crystalline, white marble, the age of which is sufficiently attested by

[* The measurements in this paper are German.—Trans.]
† See the Map above-mentioned.

its rare but recognizable fossils *. When the marble and clay-slate alternate with each other in beds of varying thicknesses, the latter has quite an altered character. It has become harder and more compact, partly allochroitic, partly passing into a nearly pure siliceo-calcareous mass. The surfaces of contact between the limestone and the altered clay-slate are frequently traversed with crystallized garnet. The garnet is locally so prevalent that thin clay-slate beds appear quite changed into masses of garnet, or are represented by accumulations of garnet crystals. Moreover a mineral similar to tremolite, accompanied by interspersed zinc-blende, is found at some points near the edge of the granite. The development of these minerals and metamorphosis of the strata have taken place in general without any particular disturbance of the stratification. This is especially observable on the sides of the quarries which are worked for the marble. Beds of altered clay-slate, sometimes scarcely more than a line in thickness, continue parallel and rectilinear for long distances. Still there are places where such beds are much cracked and fissured, and on the rock-surfaces appear almost like bran in bread. It is therefore evident, that the limestone, before it took on its present crystalline character, was in the condition of a plastic mass, in which the clay-slate lay as a harder body.

Calciferous Clay-slate and Granite between the Kjenner mines and the Ulve-Vand.—On the Paradies-Bakken we were made acquainted with the changes that the neighbourhood of the granite had produced in an area of clay-slate very rich in limestone; from the tract within the above-mentioned points we recognized the changes arising from a similar action on a clay-slate on the whole destitute of limestone, or rather only impregnated with more or less carbonate of lime. These conditions are shown approximately by the following diagram, in a vertical section:—



Here *a* is granite; *b*, an allochroitic bed, with much crystallized garnet, from a few feet to a much greater thickness; *c*, hard (altered) clay-slate, only here and there allochroitic; *b′*, an allochroitic bed similar to *b*; *c′*, hard clay-slate, gradually (but only within extensive tracts) passing into a generally soft clay-slate. It is evident that *b* and *b′* have formerly been calciferous, *c* and *c′*, on the contrary, non-calciferous clay-slate beds, and hence the explanation of the apparently paradoxical occurrence of *c* between *b* and *b′*.

Both in the Gjellebäk and Kjenner mines district, and at many other places along the granite border, there are points where the hard

* In particular I noticed a *Catenipora* in the Geological collection of the University of Christiania.

clay-slate comes immediately upon the granite, without any trace of the allochroitic formation, still less of the crystallized garnet, to be observed. In such cases the hard slate is usually penetrated by the granite. On its surface, when weathered, is seen an elaborate network standing out in relief, in which felspar is recognizable as a component part.

As we pass along the allochroitic beds *b*, *b'*, we are sometimes strongly reminded of gneiss. Numerous parallel lines of quartz, such as are met with so abundantly in the old gneiss of Norway, traverse it, and we almost forget that it is garnet and not mica and felspar that lie between them. These allochroitic beds, bordering on the granite, are also characterized by the following metallic minerals. Magnetic iron, partly granular and crystalline, and partly developed into distinct crystals (combinations of Rhombododecahedrons, Octahedrons, and Hexahedrons). Iron-pyrites. Copper-pyrites. Bismuth-glance (this apparently occurs only near the Gjellebäk mine). The presence of copper-pyrites has led to mining operations here in former times.

Limestone, Clay-slate, and Granite to the South of Drammen.—If we go from Gjellebäk south-westwardly, along the main direction of the strike of the limestone and clay-slate rocks, over the border of the granite, down the Paradies-Bakken, and across the Lier and Drammen Valleys, at a distance of about two miles we reach the edge of the granite on the other side of the town of Drammen, and there find another limestone and clay-slate area in contact with this abnormal rock. On the whole there is a repetition here of the conditions before noticed, partially, however, with their character still more strongly marked. Granular crystalline limestone and allochroitic and otherwise altered clay-slate occur over a larger extent—an area of transition rocks, about 2 miles long and ½ mile broad, being enclosed on both sides by granite. But what still increases the degree of metamorphosis, is the interpenetration of the clay-slate and granite, observable in some mines here. The granite, therefore, in this district had abundant opportunity of exercising its mighty influence; nor has it failed to do so. Not only has it awakened, as it were, the force of crystallization within the limestone and clay-slate, but it appears also to have occasioned the formation of many mineral veins along its borders. Of the minerals that thus owe their origin more or less directly to the granite, the following are particularly to be enumerated. Magnetic iron in flat patches and in streaks within the allochroitic zone. Garnet in extremely large quantities. Copper-pyrites. Zinc-blende. Iron-pyrites. Lead-glance. Iron-glance*. Cobalt-glance, sprinkled through a large flat band of magnetic iron. Quartz. Calc-spar. Fluor-spar (nearly always in Octahedrons, not

* This I find only in fragments of vein-ores on the rubbish-heap of one of the Eckholt mines. These specimens consist of a breccia of hard clay-slate and which exhibits the following characters. The individual clay-slate fragments were at first slightly surrounded with iron-glance, or rather iron-glimmer (reminding one of some Vesuvian phenomena). On this quartz crystals had been deposited, and the remaining space was filled up with calc-spar and fluor-spar.

so frequently in Rhombododecahedrons), occurring partly in the altered Transition beds, partly in the mineral veins. In an area of scarcely a square mile there are more than thirty old mines, and in other parts of the district many more mines and diggings have been worked.

The siliceo-calcareous streaks (thin clay-slate bands) occurring in the marble are nowhere in this district parallel, nor in the broken condition above described, but form, like the felspar in the hard slates, a kind of irregular network, which, from weathering and the action of water, sometimes projects ½ an inch beyond the surface of the marble.

Examples of the metamorphosis of the fossiliferous limestone and clay-slate may be taken from many other parts of the Transition district of Christiania; but the above are the chief phenomena of importance. The occurrence of the following minerals, however, deserves mention. In the district of Vestfossen (between Drammen and Kongsberg), in the Kirchspiel Eger, a finely crystallized Vesuvian is found, under similar conditions as the garnet at the before-mentioned localities. At the Hörtekolle, a mountain 1½ mile to the north of Gjellebäk, Helvine occurs with garnet; this is rare. In Allochroitic strata of the Brevig district I saw limestone-nodules (quite similar to those occurring near Christiania) which were streaked with a great number of small crystals of Scapolite.

It is worthy of remark that no trace of mica appears in the districts we have so rapidly traversed, either in the clay-slate or in the marble. If we are to look for this as a product of the contact of rocks, we should not look for it in that portion of the metamorphosed clay-slate district, the calcareous components of which have favoured the formation of garnet. Garnet and mica appear to hate each other. Let us make, therefore, a digression to the Alun-Vand, 1 mile north of Christiania. Here occurs some clay-slate apparently destitute of limestone, lying in patches of limited extent (the largest not a quarter of a mile long and of still less breadth) in the midst of the granite and very much penetrated by granitic veins and masses. Resulting from these conditions, a fine-scaled, dark tobacco-brown mica has been developed in the clay-slate near its junction with the granite. The clay-slate possesses throughout a gneissoid aspect, without however being liable to be mistaken for the normal gneiss of Norway, and we recognize a perfect similarity to the famous locality at the Sölvsbjerg in Hadeland, 7 miles N.N.E. of Christiania.

Crystalline Limestone near Christiansand.—We must now set out on a longer journey, to become acquainted with the interesting phenomena of the crystalline limestone of the district of Christiansand, 35 miles direct S.E. of Christiania. Gneiss prevails here far and wide, with a strike approaching the direction of the meridian, and in general with its usual steep or vertical dip. In *this* gneiss we meet with no crystalline limestone. Where such does occur, it is in either horizontal or apparently very indistinctly bedded gneiss, the relation of which to the vertically bedded gneiss is not understood. The stratification of the gneiss containing limestone is chiefly indicated

by the parallel lines of hornblende; these not unfrequently in their unvarying horizontality pierce far into the crystalline limestone, which generally has quite a sharp line of junction with the gneiss. Still there are apparent sometimes small disturbances of the stratification very near the limestone, which at one place indeed sends out a small vein-like projection into the gneiss.

This limestone can scarcely be termed marble, it is so coarsely granular. The numerous quarries afford favourable opportunities for mineralogists to search the limestone well for minerals; and the following occur in considerable abundance. Garnet. Vesuvian. Scapolite. Augite. Chondrodite. Spinel-ruby (Pleonaste). Felspar, with a greasy lustre and of a greyish colour. Mica, light greenish grey; rare. Sphene. Magnetic iron. Magnetic pyrites. Molybdenum-glance. Garnet and vesuvian occur in very numerous crystals, some remarkably large and fine, and form conjointly a coating to the limestone enclosed in the gneiss. Just as we found these minerals developed at Gjellebäk, Drammen, &c., on the contact-surfaces of the clay-slate and the crystalline limestone, we find them here also at the junction of the hornblendic gneiss and the marble. The extent of the coating to the marble lying within it is, however, very different. In the smaller bands of limestone, which are scarcely more than a few fathoms in length and a few feet or ells in breadth, the garnet and vesuvian generally increase so much in quantity that they almost pass through the marble band. It is quite otherwise with the limestone beds on the eastern side of Torisdal River, opposite the Eeg Palace, that have a considerable thickness, and are worked in quarries. In these the coating is very limited and indeed in some places is quite wanting. By close examination of the edge of the garnet and vesuvian, we can see that the crystals of vesuvian are placed immediately on the gneiss, and that their free extremities project into the marble; and this is likewise the case with the garnet crystals. But where the two occur together, the crystals of garnet are always placed on those of the vesuvian. That the formation of the garnet is of a later date we also perceive clearly, as we sometimes find crystals of vesuvian penetrated by small garnet veins; and this is the more readily seen, as the garnet is always of a brownish-red colour, and the vesuvian is greenish-brown or brownish-green*. It is worthy of remark also that the gneiss in the vicinity of the marble is frequently traversed by streaks and lines of garnet, whilst the vesuvian on the contrary is never found within the mass of the rock. When scapholite crystals occur, they are usually set between the garnet and the vesuvian on the gneiss; but smaller isolated crystals are also found disseminated here and there in the limestone. The crystals of sphene

* At the before-mentioned locality in the vicinity of Vestfosser, where vesuvian has been developed on the contact-surfaces of the Transition clay-slate and the limestone, some garnet is also occasionally met with; and here the same conditions hold good with respect to colour, as well as to the respective time of the formation of these two minerals. A more exact chemical examination of garnet and vesuvian thus occurring together would be of great interest.

also (which at a locality near the Gill-Vand occur more than 2 inches in length) are isolated, and limited to the garnet and vesuvian zone. Augite (the so-called Funkite) occurs as a widely distributed ingredient in some of the calcareous beds. Crystals, of the size of a mustard-seed up to the length of some lines, are scattered through the whole of the calcareous mass and give it a peculiar punctated appearance. Where the usual coating on the limestone is wanting, we meet with it on the gneiss and often to a somewhat greater extent. We can also here recognize that the hornblende, which is present as a more or less predominating ingredient of the gneiss, is converted into augite by the contact with the limestone. This is visible in a band at places scarcely more than $\frac{1}{2}$ to 1 inch broad; sometimes, however, it penetrates deeper in the gneiss, the structure of which is otherwise unchanged. As regards the rest of the minerals above-mentioned, their occurrence is quite sporadic. The chondrodite is interspersed here and there; and sometimes its imperfectly formed roundish crystals are gathered into nests and small groups; as is also the case with the spinel-ruby, mica, and magnetic pyrites, which we find also in small parcels at other places in the limestone.

Crystalline Limestone of the District of Arendal.—Arendal lies about 8 miles to the north-east of Christiansand, and within the same great gneiss district of South Norway. In the limestone of Christiansand we found evidence enough to lead us to theorize on the origin of the rocks and the formation of their mineral contents; but the phenomena of the Arendal limestone are ambiguous enough. The numerous scattered nodules, veins, and patches of crystalline limestone, or rather of extremely coarse-grained compact calc-spar, occur indeed partly in indistinctly, and sometimes horizontally, bedded gneiss, yet they are met with also in connection with the great layers of magnetic iron of this district in steep and vertically bedded gneiss. The general and great mineral richness to which Arendal owes its fame in the mineralogical world is due in no small degree to the occurrence of the crystalline limestone. This rock contains, Garnet (with Colophonite), Augite (with Coccolite), Epidote, Hornblende, Oligoclase, Orthoclase, Quartz, Scapolite, Sphene, Apatite, Zircon, Spinel-ruby (very rare), Chondrodite?, &c. The total absence of vesuvian is conspicuous in comparing these with the Christiansand group of minerals. Epidote, which does not occur at Christiansand, is here one of the abundant minerals. Its crystals, as far as my experience goes, are always set upon the gneiss; and in some measure they represent the vesuvian. The garnet crystals occur in like manner, still they are found (especially the colophonite) imbedded in the limestone mass. The same holds good with the augite; its fixed isolated crystals appear mostly as coccolite, and represent the augite (funkite) of the Christiansand district. At a few places, as, for example, near the Barbo mine, we see garnet and epidote (pistazite), like layers alternating one with another, and so in some measure representing the gneiss, which here exhibits the same stratification as the former. At Arendal I have examples of the coating of the limestone quite corresponding to that at the last-described

localities. For other particulars I must refer to a former paper of mine *.

Phenomena of quite an analogous character to those of Christiansand and Arendal are met with at many other Scandinavian localities. With reference to this I will mention only the crystalline limestones of Åker, Sala, and Tunaberg. The spinel-ruby from the limestone quarry of Åker is sufficiently well known. We here also meet with Garnet, Mica, Serpentine, Chondrodite, &c. The marble of Sala, so rich in various minerals, contains, according to Hausmann †, Malacolite (according to H. Rose remarkable for containing a large proportion of water), Tremolite, Garnet (rare), Quartz, Chlorite, Serpentine, Talc, Asbestos, Lead-glance, Zinc-blende, Iron-pyrites, Magnetic pyrites, Magnetic iron, Copper-pyrites, &c. Still richer in minerals is the Crystalline limestone of Tunaberg, of which A. Erdmann ‡ has lately given us some very interesting accounts. In it there occur—Garnet, Malacolite, Spinel (Pleonaste), Chondrodite, Scapolite, Coccolite, Epidote, Serpentine, Chlorite, Quartz, Amphodelite, Gillingite, Hedenbergite, Hisingerite, Graphite, Sphene, Cobalt-glance, Copper-pyrites, Blende, Iron-pyrites, Magnetic pyrites, Magnetic iron, Iron-glance, Molybdenum-glance, Massive Bismuth, &c.

If we consider the geognostical and mineralogical phenomena, sketched in the foregoing pages as presenting themselves in various districts of Norway, to be so many links or stages in a great Transition series or process, we may interpolate the links or stages that are wanting. We can then follow up a clay-slate and limestone formation from its original deposition under water to the stage in which it is presented as gneiss and marble with a multitude of foreign mineral contents. We see these included minerals, which now appear to us not as accessories, but as belonging to the genetical conditions of the rock, develope themselves from the ingredients which were in part originally within the limestone and clay-slate, but evidently in part also introduced at a later period. As components of the latter kind we may particularly mention Fluor (in the Chondrodite, Fluor-spar, Mica) and combinations of sulphur with metals (sulphurets of zinc, copper, lead, and bismuth).

Whatever geological theory we may embrace,—to whatever natural force we may ascribe the chief part in these operations,—we must believe in a metamorphosis as taking place here. The theory of metamorphism has of late years taken possession of minds as well as of rocks! And indeed the primordial gneiss of Scandinavia sees its privilege of aboriginality endangered! Still we may easily go too far in the Metamorphic as in the Water theory. Is there possibly within the region of the so-called Primordial Gneiss more than one gneiss formation? This important question, which Keilhau raises in the third part of his *Gæa Norvegica* (p. 367), cannot at present be

* Leonhard und Bronn's Jahrbuch, 1843, p. 631.

† Reise durch Scandinavien, vol. iv. p. 268. Hausmann recognized that the marble of Sala is interstratified with the gneiss, whilst others had previously regarded it as lying on the gneiss.

‡ Kongl. Vetensk. Akad. Handl. 1848.

answered with certainty, although it is undeniable that certain conditions appear to speak in favour of it in the Christiansand and Arendal districts, as well as in many other tracts of Norway (Sätersdalen, Hekkefiord, Krageröe, Modum, &c.). We may perhaps accord a primordial character to one portion of the gneiss.

With respect to the *causes* of the metamorphosis we have been considering in the clay-slate and limestone, we may be certain according to what we know of analogy, that at any rate heat has formed one of these causes. That water also has taken part in the operations is possible and indeed highly probable; since strata deposited in water would still be under aqueous conditions during their transformation, and would be subjected to pressure from the overlying mass of water. Scarcely, however, ought we to ascribe to water so much power as to extinguish, as it were, the fire of the Plutonists. Indeed the facts speak forcible against a Neptunism, such as that in former times hastily sketched, and in later times cleverly drawn, still scarcely true to nature.

[T. R. J.]

On the Drift Phenomena *of* Switzerland.
By A. Escher von der Linth.

[Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1852, p. 726; and Heer and Escher, two Memoirs (on the District of Zurich in the later Geological Periods). Zurich, 1852, 4to, with plates.]

The author gives the history of our knowledge of the erratic blocks, sketches the outlines of the theories that have been founded on them, describes the phenomena in Switzerland particularly, and lays down on a map the distribution of the blocks in that region, with reference to their respective local origins, their line of passage, and especially the position of the long mounds of blocks or moraines, throughout Switzerland and the neighbouring countries. Lastly, he offers a clear explanation of the so-called Ice-period and its termination. He has no doubt that the glaciers of Switzerland had really once the enormous magnitude and extent which the moraines and erratic blocks still indicate. A long series of rainy years at the present time causes the glaciers to rapidly descend far down the valleys, if there be no south wind [Föhn], which in a very short time can thaw the greatest accumulation of ice and snow. Without this south wind (and the Gulf-stream! *Ed. Jahrb.*), Switzerland would have a climate like that of the most southern part of America, the latitude of which corresponds to that of Lugano and Tessin, and where the glaciers at present come down to the sea*. This south wind, however, dates

* Compare Hopkins, Quart. Journ. Geol. Soc. vol. viii. p. lx. *et seq.*, and p. 56 *et seq.*—[Ed. Jahrb.]

back its origin no earlier than to the existence of the Sahara, whence it comes; and, according to Ritter's showing*, the Sahara was a sea at a comparatively late period.

[T. R. J.]

On the DISTRIBUTION *of the* METALLIFEROUS ORES *in* SERVIA. By J. ABEL.

[Jahrb. d. Reichs-Anst. 1851, vol. ii. p. 57 *et seq.*; and Leonhard u. Bronn's Jahrb. f. Min. u. s. w. 1852, p. 736.]

IN nearly all the valleys throughout the mountainous part of the country, there are heaps of scoriæ and other traces of the former extent of the mining works which were carried on under the Roman government. In the Maidanpek district in the mountain-ranges of Staritza and Pomont Valalb, and more than a mile [German] long by 500 to 600 fathoms [Klafter] broad, mica-schist prevails. The ores are found in a vein of syenitic porphyry of more than 100 fathoms. Limestone occurs on the heights, but it only here and there extends down into the valley, and forms steep precipitous rocks, especially where a mining town stood and where the ruins of a church are still seen. In the syenitic porphyry vein traversing the mica-schist are colossal vein-blocks of copper-ore, grey copper-ore, blue carbonate of copper, siliceous malachite and copper-pyrites, also brown ore and iron-pyrites, and lead-glance. Not far from Milanowatz the mica-schist contains garnet in abundance, and imbedded layers of hornblendic rock. The Rudna-Glawa mine was worked on a 4-fathom vein of magnetic iron, garnet, copper-pyrites, and carbonate of copper. Here the geognostic conditions are manifold, as at Maidanpek; Limestone, Serpentine, Clay-slate, Syenite, Mica-schist, and Granite occur. Below the village of Kuczama is a deserted mine, which was worked for argentiferous lead-glance in the porphyry traversing syenite and limestone.

[T. R. J.]

* Erd-Kunde, 1817, vol. i. p. 396–403.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On LIMESTONES *in* CRYSTALLINE SCHISTS *. By B. COTTA, of Freiberg.

[Zeitschrift d. deutsch. geol. Gesellschaft, 1852, 4 Band, 1 Heft, p. 47–53.]

THE metamorphosis indicated in the foregoing observations by M. Scheerer may, it appears to me, be followed up further than to the mere local conditions of crystallization. The limestone has often been softened (by heat), to a greater degree indeed than the rocks enclosing it. In this softened condition it has then been squeezed into the neighbouring fissured rocks, in an eruptive form, from out of its original place of deposition, so that, besides regular beds, it now sometimes forms also veins, ramifications, and block-like masses in them,—it has disturbed their lamination or bedding,—and encloses fragments or separated laminæ of these rocks. Would not a like result happen if we were to arrange alternating layers of wax and glass or lead and glass and subject them to heat and unequal pressure in different directions, so that the wax and the lead would soften and melt and the glass remain unmelted? The softened or melted state of the limestone was then succeeded by a crystallo-granular consistency, accompanied by the formation of substances at the line of junction of the rock-masses, which chemistry may readily explain. In considering the subject in this view, we must take care not to regard the granular limestone in the same light as the true pyrogenous eruptive rocks that have been poured out like lava from the interior of the earth. To exist in an eruptive form as the result of melting is evidently quite different from being ejected from subterranean sources. This view, which has been urged by C. Leonhard, I have before now sought to establish in the case of the granular limestones of Miltitz †, Schwarzenberg ‡, and Striegisthal § in Saxony, and also of Auerbach ||

* This paper has reference to M. Scheerer's paper, *supra*, page 4, and to M. Delesse's paper on 'Limestone in Gneiss,' Annales des Mines, tome xx.

† Jahrb. f. Min. 1834, p. 319; and Geognostische Wanderungen, part 1.

‡ Erläut. d. geogn. Karte von Sachsen, part 2. p. 242.

§ Jahrb. f. Min. 1851, p. 572.

|| Grundriss der Geog. u. Geolog. 1846, p. 304.

in the Bergstrasse. A great many localities might be quoted for this purpose, if one would take the trouble carefully to compare all the local descriptions relating hereto. That, however, is little in accordance with my design, for I well know that it is dangerous to endeavour to explain in particular points of view the observations of another, when the observer himself was not actuated by those views nor had them in the least in his consideration. Having offered these general remarks, to which the concluding part of M. Scheerer's paper has given rise, I will confine myself to the expressed wish of M. Delesse, to notice briefly some few particulars, of my own observation, relating to the occurrence of granular limestones in crystalline schists; a phænomenon also that is in part connected with that group of minerals, which, it appears to me, generally where they occur to any extent, originate in the contact of limestone with siliceous or clay-slates.

Limestone of Tharand near Dresden.—Near Tharand the unfossiliferous clay-slate contains a fine-grained, grey, and somewhat dolomitic limestone, in a layer-like mass sometimes of considerable thickness. At the upper and lower surfaces of the limestone are very numerous alternations of thin laminæ of limestone and clay-slate. The limestone is traversed by the great Tharand quartzose porphyry vein, and along the line of junction of the vein and the limestone there are sometimes peculiar drusy breccias, in which limestone fragments are cemented together by calc-spar and brown-spar. Between and in the fragments druses have been developed, so that sometimes merely the walls of the druse cavity, only a line in thickness and forming the outer surface of the fragment, is all that remains. In the druses are found crystals of Brown-spar, Calc-spar, Heavy-spar, Gypsum, Iron-pyrites, Copper-pyrites, Lead-glance, and Blende, but none of those minerals that are so characteristic of the contact-surfaces of limestone and siliceous rock. A perfect melting and commingling has not taken place at Tharand; there is evidence only of a low stage in the process of change.

Limestone of Zaunhaus in Saxony.—This fine and highly crystallo-granular limestone lies in the mica-schist of the Altenberg district, and is parallel with its lamination. Above and below here also are numerous alternations of limestone and mica-schist laminæ. If we fancy the Tharand limestone next to the enclosing clay-slate in a somewhat higher stage of change (but not absolutely melted), we have before us the Zaunhaus conditions. The whole mass of the Zaunhaus marble, however, is moreover permeated by a large quantity of small white mica-flakes parallel with the lamination. It is a Cipolino.

Limestone of Wunsiedel in Bavaria.—This forms a thick and extensive bed in the mica-schist of the Fichtelgebirg, where, along a long curved line between Tröstau and Hohenberg, it has given rise to a great number of quarries. It offers the appearance of a regularly intercalated bed in the mica-schist, but it has lenticular thickenings, and between these thicker portions it sometimes almost disappears. At its surface this, like the very similar limestone of Arzberg-Redwitz, is often accompanied with brown iron ore, which has apparently resulted from the decomposition of spathose iron-stone. The limestone

is for the most part fine, white, and crystallo-granular, somewhat rich in magnesia, and at many places a true dolomite. As accessory ingredients, it contains Tremolite, Garnet, Talc, Serpentine (at Thiersheim), Fluor-spar, and Graphite. At Göpfersgrün the mica-schist bordering on the limestone contains Idocrase. Perhaps the south-west continuation of this bed is represented by a kind of [Erlanfels] in the mica-schist beyond the Fichtelgebirg granite.

We evidently have here to do with a large mass which for a long time has consisted of a combination of granular limestone, dolomite, and spathose iron, the last of which has been converted into brown iron-ore. May we not regard this whole group of intimately combined rock-substances to have originally consisted of clay-slate with thick beds of limestone, partly dolomitic, and of carbonate of iron, such as very often occur together in the coal-formation? The mica-schist has resulted from the clay-slate, marble from the thick limestones, spathose iron from the sphærosiderite, and at a later period by a different kind of change, the brown-ore from the spathose iron.

At Stemmas, not far from Thiersheim, the limestone is distinctly penetrated by numerous granite veins; hence it appears that the great Fichtelgebirg granite district bordering on the mica-schist to the north is altogether of a later origin than the mica-schist with its included beds, and also that perhaps it had a share as a cause or promoter in the metamorphosis of the whole.

Limestones of the district of Schwarzenberg in Saxony.—In the mica-schist at Schwarzenberg occur a great number of granular limestones and dolomite that have long been used as fluxes by the iron-smelters, and termed "Flösslager." These so-called beds (as I formerly noticed in my 'Explanation of the Geological Map of Saxony,' part 2. p. 343) are not true layers, but flat masses, forming veins and occupying fissures, which run nearly parallel with the direction of the lamination,—sometimes contain fragments of neighbouring rocks, or, cutting through the lamination of the mica-schist, form ramifications, and at no place exhibit those numerous alternations along the contact-surfaces, as we observed at Tharand and Zaunhaus; but on the contrary they have nearly always a clearly defined line of demarcation above and below. These limestones are very often accompanied with beds of ore, which lie in the mica-slate in a position quite analogous to that of the limestones, and the relation of contact-formations and including rock is preserved throughout. The ores form immediately either the bottom or the top of the limestone, and are remarkable for their richness in various minerals: they have supplied—Hornblende, Actinolite, Chlorite, Garnet, Vesuvian, Allochroit, Konpholite, Peponite, Sahlite, Pistacite, Mica, Talc, Picrolite, Tremolite, Serpentine, Steatite, Felspar, Diopside, Zoisite, Helvine, Axinite, Prase, Magnetic iron, Magnetic pyrites, Iron pyrites, Copper pyrites, Arsenious pyrites, black and brown Blende, Lead glance, Tin ore, Scorodite, Arseniate of iron, Calc-spar, Barytes, Fluor spar, Bitter spar, Gypsum, Metaxite, Cerolite, Molybdenum, white and green Lead ore, &c., which must certainly have come into existence under different conditions and at different times.

The original cause of their formation appears, however, to be connected with the mutual occurrence of limestone and siliceous rock (mica-schist and greenstone).

We ought certainly to mention that the limestone sometimes occurs in the mica-schist of this district unaccompanied by the ores, and also that very often rocks of the greenstone character and rich in ores are present in the mica-schist without any limestone traversing the schist in their neighbourhood. Calcareous beds or injections, of but small extent, may however possibly have been employed under particular circumstances wholly in the formation of such aggregations of minerals. This supposition is strengthened by the analogous case of the so-called [Erlanfels] in the same district, which appears to have originated in an intimate commingling (by heat) of greenstone and limestone.

The Limestone at Miltitz, near Meissen, is fine, white, tolerably pure, and granular; it generally lies parallel in the hornblende-schist, but at its borders it sends small ramifications into the latter. It also contains fragments of the schist and even of granite and quartzose porphyry, which latter it must have taken from elsewhere than its own locally disturbed region (unless perchance they were present in the earlier thick limestone beds). At the contact-surfaces of the schist and limestone there are, at Miltitz, traces of, as it were, a melting together, but few particular minerals. As such I know only of Garnet, Tourmaline, and Iron-pyrites. The Tourmaline indeed may have belonged perhaps to the enclosed granite fragments.

Near Auerbach in Bergstrasse a fine granular limestone forms a vein from 20 to 50 feet thick in the gneiss, granite, and syenite. Its border consists in part almost entirely of Idocrase, Garnet, Epidote, and Wollastonite. Disseminated in the limestone there are also Hornblende, Grammatite, Iron-glimmer, Marcasite, and Copper-pyrites. In the neighbouring gneiss there occur some separate veins of Magnetic iron-ore.

The Dolomite of Memmendorf near Freiberg belongs to the gneiss; it is traversed by veins, but shows no particular minerals on the contact-surfaces, although it is exposed in many mines and quarries.

The Crottendorf limestone is the most important in the Erzgebirg gneiss district. In one of the large quarries opened in it, it exhibited (1838) extraordinarily violent bendings and twistings of the beds—a perfect jumble of curves, slips, anticlinals, and synclinals. The limestone is snow-white, passing to greyish and reddish white, small and fine-grained, and not unfrequently mixed with talc-like mica-flakes, which, when abundant, produce a kind of lamination. It contains Iron-pyrites, Tremolite, and Slate-spar.

Lastly, I will here mention that the so-called Egeran (Idocrase), together with Pericline, Garnet, and Grammatite, at Haslau, near Eger, also belong to a granular limestone bed or vein in the midst of the granite district.

[T. R. J.]

On the SACCHAROID LIMESTONE *in the* GNEISS *of the* VOSGES. By Prof. A. DELESSE*.

[Annales des Mines, 4 Ser. vol. xx. p. 141 *et seq.*]

THE saccharoid limestone in the gneiss of the Vosges is met with at Chippal, Laveline, Gemaingoutte, Wisembach, Sainte Marie, and Sainte Croix aux Mines. It is always completely enveloped by the gneiss, in which it forms irregular or lenticular masses, like those which have been noticed as occurring in Scandinavia by MM. Scheerer and Keilhau. These Vosges limestones have been incidentally noticed by former writers, and are remarkable for the beauty and great variety of the minerals they contain.

Chippal.—The saccharoid limestone of Chippal, near Croix-aux-Mines, forms an irregular mass, of 15 to 20 metres in width, and 50 in length; and is enclosed in a schistose gneiss, which contains quartz, orthose, and much brownish mica. The limestone is traversed by a granitoid rock†, of a rose or brownish colour, granular in structure, and almost entirely consisting of orthose-felspar. Being much penetrated by calcareous matter, it effervesces strongly with acids. The gneiss and limestone appear to have been brought together in a melted state and to have mutually interpenetrated each other, the irregular granitoid veins being injected into the latter. At its contact with the limestone the granitoid rock is edged, to a thickness of several centimetres, with a hydrosilicate, which is green, with a greasy lustre, softer than felspar, and often accompanied or impregnated by quartz. This hydrosilicate is produced by an incipient pseudomorphosis of the felspathic matrix of the granitoid rock, and, from researches made by M. Delesse, appears to be nearly allied to the pyrosklerite noticed further on.

The line of separation between the limestone and the granitoid rock is constantly marked by a kind of seam, which is intimately connected with the limestone in the form of very thin laminæ having the structure of the *hachée* variety of quartz. These are seen by dissolving the contact-surface of the limestone in acid. The laminæ are moulded in the interstices of the cleavage of the carbonate of lime, which they represent in relief.

The Chippal limestone is a fine white marble, crystalline and lamellar, like the Paros marble; sometimes, however, it is compact. It is quarried for the marble-works of Epinal and for lime-burning. It is a pure carbonate of lime.

Several minerals occur in this limestone, especially in the quarries on the upper part of the hill. They are sometimes disseminated irregularly, sometimes they form series of nodules and druses or

* The abstract here given of M. Delesse's detailed account of the Vosges limestones forms a necessary accompaniment to the foregoing papers, on limestones in crystalline rocks, by MM. Scheerer and Cotta (*supra*, p. 4 and p. 15), who appear to have been induced to publish their observations by the publication of this Memoir, and by communication with M. Delesse on the subject.

† The relations of the limestone and the granitoid rock are shown in the plate accompanying M. Delesse's Memoir.

veins, parallel with the line of contact of the limestone and the granitoid rock, and following all the sinuosities of the latter. These minerals are Pyroxene*, Mica, and Pyrosklerite, which is white or greenish, and in some cases penetrates the limestone in the form of dendrites. Occasionally there is a little Amphibole, Quartz, and Graphite, the last in deep black, microscopic scales, rather rare. Spinelle also occurs, sometimes, in small octahedrals, bluish grey and transparent. MM. Puton and Fournet have also observed Condrodite in small orange-yellow concretions.

Laveline.—Several masses of saccharoid limestone occur near Laveline. This is a variety of the foregoing, lamellar, greyish white or light bluish grey. White felspar is often developed as veins, which are sometimes parallel, sometimes irregular. When the veins are very abundant, the limestone passes insensibly into the enclosing gneiss, the mineralogical composition of which does not differ from that given by M. Naumann for gneiss generally. The Laveline limestone, like most crystalline limestones, when bruised exhales a fœtid and bituminous odour. It contains Pyrosklerite, Tremolite, Mica, magnetic and ordinary Iron-pyrites, and a great number of minute grains of Graphite.

Sphene also occurs, in microscopic brown crystals. Quartz is often found forming veins or minute agglomerations, with very irregularly indented outlines, the crevices of which are occupied either by felspar or limestone. Pyrosklerite also accompanies these quartzose bodies at some points where the felspar is in contact with the surrounding limestone. When treated with acid, the limestone of Laveline is found to contain a large proportion of minerals, disseminated in the mass or developed within it as dendrites. Amongst these are Felspar and Quartz, which contribute to its hardness and stand out on the weathered surfaces. This limestone is quarried for the marble-works of Epinal.

A limestone exactly similar to that of Laveline, and also enclosed in gneiss, is met with at Gemaingoutte, above Velupaire.

St. Philippe.—The saccharoid limestone of the gneiss is well seen below the old workings of St. Philippe, near St. Marie aux Mines (Haut-Rhin); and the quarry in which it is worked (for lime-burning) contains such a variety of minerals that it forms quite a mineralogical museum. The limestone and the gneiss are separated more distinctly than at Laveline; nevertheless, the former is largely charged with a reddish-brown mica, which also occurs in the latter, and, in some sort, constitutes a passage from the limestone to the gneiss; and there are, moreover, many alternations of the two rocks, as may be seen in the old quarries higher up. The minerals are pretty generally developed in the limestone, and even in the gneiss, as veins, parallel to the line of junction and the lamination of the two rocks †, which dip to the S.E., at an angle of about 20°.

The St. Philippe limestone is composed of white crystalline lamellæ entangled in every direction: it is only in the fissures or in

* These minerals are described in detail by M. Delesse, *l. c.* p. 144 &c.

† See Pl. x. fig. 12. of M. Delesse's Memoir.

the geodes that the fine transparent crystals* of carbonate of lime are seen to terminate.

According to Monnet this limestone is magnesian, but the experiments M. Delesse has made together with M. Carrière show that, when it is freed from the magnesian silicates disseminated within it, it contains traces only of magnesia. This limestone is worked at some places for cement (hydraulic lime); on which subject M. Delesse offers some observations (p. 151).

The minerals disseminated in the limestone of the St. Philippe quarry are Mica (Phlogodite), Pyrosklerite, magnetic and ordinary Iron-pyrites, Spinelle, Sphene, and Graphite. These are described in full, p. 151–161. The dissemination of the mica converts the limestone locally into a *Cipolino*. Orthose, Oligoclase, Pyroxene (Melacolite), Amphibole, and Sphene (see p. 161–166) occur in small and very complex veins traversing the gneiss; and most of them are found also in nodules in the limestone, where they are associated with one or more of the disseminated minerals. The minerals in the veins have their crystals usually better developed than those in the limestone. The St. Philippe limestone is not traversed, like that of Chippal, by veins of granitoid rock with an orthose base; but it contains a great number of nodules, generally felspathic, which are met with in most of the saccharoid limestones. These M. Delesse proceeds to describe in detail (p. 166–172). They are elongated and flattened; and they form irregular and discontinued beds, which are generally parallel to the lamination both of the limestone and the gneiss. Sometimes, however, the parallel series of nodules at one level are connected with those at another by strings of similar nodules running across the lamination. These nodules correspond, in their very irregular form and disposition, with the equally irregular veins in the gneiss. The nodules are composed of several concentric, ellipsoidal zones of three minerals, separated one from another as distinctly as the nodules are from the limestone, and succeeding each other pretty constantly in the following order from without inwards,—Mica (Phlogodite), Pyrosklerite, and Felspar (Hälleflinta). The felspar, however, frequently disappears, leaving the other two minerals to constitute the nodule. The other minerals that occur in these nodular and drusic bodies are Kaolin, Orthose, Sphene, Amphibole, Pyroxene, and Quartz. In some peculiar nodules saccharoid limestone is found, with Magnetic-pyrites and Graphite.

At St. Philippe the felspar, whatever may be its character, always occupies the centre of the nodules, and M. Delesse has not found it in isolated and distinct crystals like those disseminated in the saccharoid limestone of Baltimore, Col du Bonhomme (Mont Blanc), Kaiserthal, or in the metamorphosed limestone with *Gryphæa arcuata* of St. Laurent (Saône-et-Loire).

The gneiss, which is well developed in the neighbourhood of Sainte-Marie-aux-Mines, generally contains Orthose, Quartz, and Mica, and, in certain cases, hornblendic Amphibole, Garnet, Graphite, &c. (p. 172, &c.) The gneiss that is in contact with the St. Philippe

* See Memoir, *l. c.* p. 150.

limestone is almost entirely composed of white Orthose-felspar, brownish or blackish green Amphibole, Garnet, and Mica. In the St. Philippe quarry the limestone with nodules is succeeded by a micaceous limestone, which passes into a gneiss with Garnet, Hornblende, and Mica. This is succeeded by a gneiss traversed in every direction by very irregular veins, often derived from the rock itself. These veins consist of Orthose, Pyroxene, Oligoclase, Amphibole, and Sphene. The first two are the most abundant (p. 175).

Professor Hitchcock has described a gneiss occurring in Massachusetts, which is accompanied by a great development of saccharoid limestone. This gneiss, in which Pyroxene is occasionally associated with Sphene, M. Delesse considers to be probably of the same age as the gneiss of the Vosges.

In the cavities of the St. Philippe gneiss, as well as in the druses and in the veins of orthose, are found Albite, Actinote, Asbestus, and Sphene; and M. Delesse particularly refers to the great scarcity, and even absence, of quartz in the veins and in the nodules, as well as in the gneiss forming the roof of the limestone.

Although the mineralogical composition of the *veins* in the gneiss differs somewhat from that of the *nodules*, and although they further differ in the circumstance that the former are ramified and *intimately connected* with the gneiss, and the latter are rounded and *distinctly separated* from the limestone, yet, it must be noticed, the veins and the nodules have the great proportion of their minerals in common,—especially the Orthose, the Felspar with a greasy lustre, the Amphibole, the Pyroxene, and the Sphene. Hence it is probable that they were formed simultaneously and had the same origin; and that the differences they present in their position and constitution must be attributed to the nature of their enclosing rocks respectively. Such influence, moreover, was not exercised only at the moment of the secretion and crystallization of the veins and nodules, but it has been felt during the physical and chemical conditions to which the gneiss and the limestone have been since submitted. The Pyrosklerite, for instance, appears to owe its formation to pseudomorphic action developed by the intervention of the limestone.

After some general notices of statuary marbles, and of the dolomite in the gneiss of Maudray, M. Delesse proceeds to observe that he considers the limestone and the enclosing gneiss as contemporaneous, though it would be exceedingly difficult to determine the age of the several rocks so situated with any exactitude. The saccharoid limestones of the gneiss in the Vosges, United States, Scotland, and Scandinavia are regarded by M. Delesse as being of the same age. Lastly, he observes, that the minerals of the Vosges, many of which have been formed simultaneously in the limestone and in the gneiss, are unaccompanied by metallic minerals, and that consequently the geological phænomena by which they have been developed are independent of those which in Scandinavia and elsewhere have produced metalliferous ores in similar rocks. [T. R. J.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Structure of AGATE. By THEODORE GÜMBEL.

[Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1853, pp. 152–157.]

THE curious and beautiful appearances afforded by agates have long made them of primary importance in mineralogical cabinets; but until of late years particular attention does not seem to have been paid to the internal structure of these bodies. Dr. J. Zimmerman is the first, of my knowledge, who observed* that the different varieties of quartz—as amethyst, calcedony, carnelian, jasper—formed the concentric layers of the nodules, which were either hollow or occupied with crystals†.

In the Jahrbuch of the Imperial Geological Institute of Vienna for 1851‡ is a very interesting memoir on the interior structure of agates by Prof. Dr. Franz Leydolt, where he states that, on being submitted to the action of fluoric acid, the amorphous portions are dissolved before the crystalline layers or bands; and the agate-surface being thus prepared, it is made use of in printing an exact copy of itself. The six beautiful plates accompanying the memoir perfectly exemplify Prof. Leydolt's views, and show,—first, that the parts towards the outer surface consist of several spherules variously combined, which are composed of layers of diverse character; secondly, that towards the centre of the nodule is a large mass of amethystine quartz, the nucleus of the latter again being formed of very small concentric spherules.

In the 'Jahrbuch für praktische Pharmazie,' &c. 1852, is a short paper of mine on the rotatory motion of matter in the amorphous condition, in which I have shown that in a sphere of blown glass the material is not homogeneous, but consists of lamellæ overlying one another at varying angles and confusedly distorted. As in the thin pellicle of blown glass the intimate structure of the soap-bubble is, as it were, fixed, so I sought to make further researches by means of experiment on molecular movement, such as can be observed in so many instances. One of the most successful experiments was the use of melted stearine, with which very fine graphite had been mixed, spangles of which easily indicated the intimate motion of the mass.

* In his Taschenbuch für Mineralogie.

[† See also Mr. Hamilton's Paper on the Agate Quarries of Oberstein, Quart. Journ. Geol. Soc. vol. iv. p. 215.—TRANSL.]

‡ Vol. ii. no. 2. p. 124.

By this easy experiment it appears that in some parts there was a strong tendency to the formation of spheres, and which existed even in the interior of the larger spheres, giving rise to smaller spherules.

M. Gümbel goes on to describe phenomena of a somewhat similar nature which he has observed in melted and cooling metals, such as lead and antimony; and, as Leydolt noticed that some results of the action of fluoric acid on glass* are explanatory of the structure of agate, so has the author made similar observations when sheet lead has been acted upon by the vapour of sulphuric acid. M. Gümbel offers some remarks on the different sorts of agates, and notices that the subject is in many respects of great interest, especially as regards the formation of oolite, the spherical structure of basalt, &c.

[T. R. J.]

On Matlockite. By C. Rammelsberg.

[Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1853, p. 173: Poggend. Annal. lxxxv. p. 141 *et seq.*]

The new mineral, Matlockite†, is very similar in external appearance to Corneous Lead (Murio-carbonate of Lead, Blei-hornerz), and, together with the latter, it has been found, associated with earthy galena, at the deserted Cromford mine, near Matlock. Both are very rare.

Compact fragments of the Murio-carbonate are transparent, colourless or yellowish, lustrous, and pretty generally cleavable in three directions at right angles to each other. Brooke‡ and Krug von Nidda§ describe the crystals of this mineral. Rammelsberg found its specific gravity to be 6·305. In powder it was in some degree decomposed even by cold water, chlorite of lead being set free. Its analysis is given below.

In Matlockite, a single, but very perfect, plane of cleavage has been observed. This mineral has been recognized as a basal chloride of lead. The specific gravity of the powder is 5·3947. Its analysis is—

Matlockite.			Blei-hornerz.	
Chlorine	14·12	55·62.	Carbonic acid	7·99
Lead	41·50		Oxide of lead	40·46
Lead	41·50	44·38.	Chlorine	12·97
Oxygen	2·88		Lead	37·96
	100·00			99·38

[T. R. J.]

On Glauberite *from* South Peru. By M. Ulex.

[Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1851, p. 204; and Woehl. u. Lieb. Ann. vol. lxx. p. 51 *et seq.*]

The Brongniartin or Glauberite occurs in crystals imbedded in nodular masses of a substance called "Tizza," which the author recog-

* See also Comptes Rendus, xxxi. p. 565.

[† See also Lond. & Edinb. Phil. Mag. 4 ser. vol. ii. p. 120.—Transl.]

‡ Poggendorf's Annalen, xlii. p. 582.

§ Zeitschrift d. Deutsch. geol. Gesellschaft, vol. ii. p. 126.

nized as a boracic compound. According to Frankenheim, the crystals, attaining a size of from 1 to $1\frac{1}{2}$ inch [German], differ from those of Brongniartin previously known in their angles, but slightly however; the form also somewhat differs. Sometimes the crystals appear perfect and transparent, sometimes white and laminated, the fissures being occupied by the above-mentioned substance. Spec. grav.=2·64; hardness=2·5–3·0. Its behaviour in the alembic and before the blowpipe is like that of the Spanish Brongniartin. An analysis gave—

Lime	19·6
Soda	21·9
Sulphuric acid	55·0
Boracic acid	3·5
	100·0

$$\text{Formula: } \dot{N}A\,\dddot{S} + \dot{C}a\,\dddot{S}$$

The presence of borax is no doubt due to the admixture of the mineral substance in which the crystals are imbedded.

[T. R. J.]

On the Classification *of* Rocks. By M. Dumont.

[Acad. Roy. de Belgique, Bulletins, 1852, t. xix. no. 5. p. 18.]

In this communication M. Dumont proposes a distribution of rocks and mineral deposits generally into three classes, according to the mode of their formation, and the use of the word *Geyserian* as a designation for the third of these classes*.

The chemical as well as the physical study of the crust of the earth is now beginning to engage a portion of that attention which for some years has been almost exclusively devoted to palæontology; nor can it be doubted that inquiries which may hereafter enable the geologist to explain both the physical and chemical condition of the earth's crust, are necessary to a right understanding of the past history of its successive changes. M. Dumont appears to feel this when he suggests the threefold division of the rocks and strata of the earth above-mentioned, and the adoption of a new designation for one of them. He observes that the terms Neptunian and Plutonian cannot embrace all the forms of mineral deposits. The term Neptunian naturally comprises all stratified deposits which have been formed under the action of external causes, and have therefore been called by Humboldt *exogènes*. They have been produced generally under the influence of water, exhibiting phænomena of a mechanical, chemical, or physical nature, and often containing the relics of organic bodies. Such strata which are quartzose, slaty, clayey, calcareous, dolomitic, or carbonaceous, and are either laminated, compact, sandy, conglomeratic or organic, sometimes appear nearly in the condition of their original deposit, and sometimes in a state of great alteration consequent upon the action of internal causes subsequent to their deposition, a change in consequence of which they have been desig-

* [For remarks on a class of rocks termed *Æolian*, see Captain Nelson's Communication on Coral Formations in this Number of the Journal.—Ed.]

nated Metamorphic. The term Plutonian comprises those rocks which have been produced by igneous action from internal causes, and have been therefore called by Humboldt *endogènes*. Such rocks are crystalline and sometimes cellular, are felspathic, and appear either in masses or have been erupted, like lavas, in streams.

By the term "Geyserian" M. Dumont proposes to designate those rocks which, though, like the Plutonian, they have been produced by causes acting from within, have not, like them, been fused by heat, but have been formed by either aqueous or gaseous emanations. The Plutonian, in fact, have been formed like lavas, the Geyserian like sublimed sulphur. Geyserian rocks are metalliferous, rarely felspathic, are confusedly crystalline, concretionary or cellular, and exhibit a very different aspect to that of the Plutonian. On the other hand, though sometimes conglomeratic or composed of transported materials, and formed under the influence of water, they are distinguished from the Neptunian by their want of stratification, by the metallic and mineral substances they contain, by the absence of organic remains, by a crystalline or concretionary structure, and especially by their mode of formation.

Such are the views of M. Dumont; and although, as he states, it may be sometimes difficult to draw the line of limitation between rocks of these various modes of formation, and the Geyserian may appear involved in and subsidiary, sometimes to the Plutonian, sometimes to the Neptunian, it is certainly desirable that the geologist should feel and admit that igneous fusion alone, as supposed to be recognized in plutonic rocks, or the ordinary action, whether mechanical or chemical, of water, as recognized in Neptunian rocks, cannot explain all the phænomena of rock-formations and of mineral veins; whilst the term "Geyserian" sufficiently explains the nature of the other actions M. Dumont considers to have shared in the production of the general effects observed.

[J. E. P.]

On Titanium *in the* Harz. By Fr. Ulrich.

[Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1853, p. 175: Bericht d. Verhandl. d. Clausthaler Vereins. 1852, p. 29 *et seq.*]

Zimmerman has mentioned the occurrence in the Harz of Rutile and Nigrine, which have been found in the Baste and as rolled fragments on the Ecker. Titanite has now also been met with. A short distance above the uppermost quarry of the Radau Thal there is a vein traversing a kind of mica-schist. The vein is 3 feet thick, and is chiefly occupied by crystalline, coarse-grained Orthoclase, columns of which, from $\frac{1}{4}$ to 1 inch long, are intermingled with a mineral decomposing into yellow and brown hydrated oxide of iron. The Titanite is found throughout the mass of the felspar in little particles and in crystals, of a clear and honey-yellow colour, and about 2 inches in length. The vein also bears quartz and a thick greyish white mineral, which perhaps may be Wernerite; in that case, according to Wöhler, Apatite also.

[T. R. J.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the ORIGIN *of* CRYSTALLINE LIMESTONES. By Prof. A. DELESSE.

[Bullet. Soc. Géol. France, Deux. Sér. tome ix. pp. 133–138.]

M. DELESSE, having just previously reviewed the general characters and mineral contents of different crystalline limestones*, commences this communication by defining "metamorphic limestone" and "metamorphic rock" as a rock which has been subjected, at a period posterior to its formation, to considerable modifications in its physical or chemical properties. These modifications are brought about by the development of divers minerals, by changes in its structure of aggregation, or in its structure of separation, as well as in its chemical composition. The modifications in the physical properties of the rock result from the action of heat, electricity, magnetism, pressure, as well as of all the agents that can bring into play molecular attraction and repulsion. The modifications in its chemical properties arise from the introduction of new substances in the rock by injection, sublimation, secretion, cementation, and especially by infiltration.

M. Delesse then observes,—it appears to me that the crystalline limestones should be considered *metamorphic*: though certainly they are metamorphic to very different degrees; still they have all been subjected, since their deposition, to modifications in their chemical, or at least their physical, properties. There are, however, some limestones that form an exception; namely those which have been deposited by chemical precipitation, and which were originally crystalline: these are not to be confounded with the metamorphic crystalline limestones, nor do they contain the minerals characteristic of the latter.

The crystalline limestone of the gneiss of the Vosges, which, from its mineralogical and geological characters, M. Delesse considers to

[* *Loc. cit.* pp. 120–133. See also Papers by MM. Delesse, Cotta, and Scheerer, *supra*, pp. 4, 15 & 19, *et seq.*—TRANSL.]

be a metamorphic limestone, is then particularly adverted to: its characters are succinctly described; and M. Delesse proceeds to say, that probably the limestone was originally deposited either in mass from water charged with carbonate of lime, or as strata by the waters of the sea: the beds in which the limestone has been intercalated belong without doubt to certain divisions of the Transition Group; and moreover all geologists who have studied the Vosges have regarded the gneiss enclosing the limestone as metamorphic.

The phænomena that have produced the metamorphism of the gneiss are unknown; but a group of strata could be transformed into gneiss only by the introduction of the quantity of alkalies necessary for the production of the felspar, one of the constituents of the gneiss. Further, heat must have been effective in the development of the crystalline structure of the limestone of the gneiss, since the limestone contains spinelle, chondrodite, garnet, amphibole, pyroxene, &c., that is to say, minerals of an igneous origin, since they are found in the limestones on the flanks of Vesuvius, or in the sphere of action of other volcanoes now active, such as those of Teneriffe, Ponza Isles *. On the other hand, there could not have been complete fusion, for in the crystalline limestone of Norway MM. Naumann and Keilhau have observed fragments of corals †.

The nature of the very numerous minerals of the crystalline limestone also gives great improbability to the hypothesis of complete fusion. It appears indeed that rocks which have been reduced to a fluid state, and which have had an igneous origin, such as Lavas, have always a very simple mineralogical composition. They are essentially formed of two minerals; the one, of the felspar class, in which are concentred the alumine and the alkalies; the other, of the pyroxene or peridote kind, in which are concentred the oxide of iron, magnesia, and lime. In "crystalline limestone," on the contrary, there are various silicates, sometimes with a single base, sometimes with many; and these silicates are often associated either with free silex, or with silicates not saturated with bases; moreover, together with these silicates, there are very energetic, uncombined bases, such as magnesia (periclase), alumine (corindon); there are also metallic oxides, such as the oxides of iron, which, under certain circumstances, appear to have been contemporary with the limestone; and there are compound oxides, such as the spinelles, perovskite, in which the oxide playing the part of an acid (alumine, titanic acid) is an acid much less energetic than the silex. We easily comprehend then that these minerals have been formed with the concurrence of heat, or of the molecular actions which it developed; but it is difficult to admit that they result from a complete fusion of the crystalline limestone.

Moreover many facts prove that felspar may be formed in rocks without the intervention of a great heat; for example, in the arkose of La Poirie (Vosges) crystals of felspar are developed in the clay-

* Dufrénoy, Ann. des Mines, 3 sér. tome xi. p. 385.

[† See also Translation of Prof. Scheerer's Memoir, *supra*, p. 7.—Ed.]

beds (argilolites), which certainly have not been melted, and the stratification of which is quite recognizable. At Morel, in the Commune of St. Laurent (Saône-et-Loire), crystals of pink orthose, of an after-development, exist in a limestone with *Gryphæa arcuata*, which has a crystalline structure, but characterized by a greyish yellow tint somewhat different from its usual colour. Lastly, at Steinmal, felspar-crystals have been observed by M. von Dechen in the inside of the abdominal buckler of a *Homalonotus*. In the same manner, the Transition greywackes in the neighbourhood of Thann and to the south of the Vosges are very often completely impregnated with felspar, and still we find in them numerous remains of plants which have been well preserved in spite of the later development of crystals of felspar of the sixth system.

The intimate and mutual penetration of the limestone and gneiss shows that both have been reduced to a plastic state, if not to actual fluidity; and the dissemination of the felspar in the limestone mass shows also that the gneiss must have been sufficiently pasty for the felspar to have been secreted.

The penetration of the limestone by the gneiss, as also the undulations sometimes presented by both rocks at the line of junction, make it evident that pressure was brought into play to a great extent during the crystallization of the gneiss; this has produced in the limestone fissures generally parallel to its line of contact with the gneiss, and comparable to those formed in a book, the leaves of which are squeezed or pressed back laterally. These fissures have been immediately filled by the secretions of matter diffused in the limestone, and they have given place to the parallel zones of nodular concretions*, whilst the same matter formed the veins or the lining in fissures of the gneiss. Although in most of the metamorphic limestones the minerals are especially developed in the natural joints originating in stratification, these nodules, on the contrary, in the limestone of the gneiss of the Vosges, apparently owe their parallelism to pressure.

Pressure, like heat, has been also effective in actuating molecular attraction and in developing the different minerals disseminated in the limestone.

Subsequently to the crystallization of the limestone and of the gneiss certain minerals have been, and probably are still being modified by chemical action arising from infiltration, so that new minerals are formed by pseudomorphosis; as for example, the pyrosklerite.

[T. R. J.]

On the Formation *of* Crystallized Minerals. By Aug. Drevermann.

[Annalen der Chemie, 1853, vol. lxxxvii. p. 120.]

A series of experiments with which I have been lately engaged seem to throw some light on the formation of crystallized minerals

[* *Vide supra*, p. 21.]

from aqueous solutions. I started upon a conviction that crystals found in geodes could have been formed neither by evaporation nor by refrigeration of saturated solutions, and I think I have succeeded in discovering the mode of formation of such minerals. The method is equally applicable to very soluble or slightly soluble bodies, and admits of an infinite variety of modifications in its mechanism. Its principle is nothing else than a gradual alteration of the affinity of the solvent for the dissolved body, so that the precipitation occurs very slowly. The gradual change of chemical force is obtained by the diffusion of one liquid into another, such as in mixing produce a solid precipitate. The arrangement of the apparatus is the same as in Graham's experiments. Powdered chromate of potash was placed in the bottom of a long glass cylinder, and powdered nitrate of lead in the bottom of another; both were then filled with water, and placed in a large beaker-glass which contained water enough to cover the two cylinders. In a few months the nitrate of lead had diffused out into the beaker-glass and formed several beautiful amorphous compounds on the edge of the cylinder in which the chromate had been placed. In the interior of the cylinder, beautiful pink, highly refractive needles of Rothbleierz (PbO, CrO_3) were deposited, also little dark red rhombic plates of Melanochroit ($3PbO, 2CrO_3$). The needles of neutral chromate found in this manner attained to three or four millimetres, and then fell to the bottom of the cylinder, where the conditions of their development were wanting. Had it not been for this circumstance, they would, no doubt, in three or four months, have got to half an inch, or even more. Some crystals of Weissbleierz (PbO, CO_2) formed in the same vessel, owing no doubt to the circumstance that the chromate contained some carbonate of potash. In a similar manner I obtained crystals of calcspar, also rhombic plates of $2CaO, HO, PO_5+4HO$, and some shining needles which I believe to be $3CaO, PO_5$.

As this method is perfectly general in its principle and proves applicable to such compounds as carbonate and chromate of lead, we may safely affirm that the insolubility of a compound will no longer prevent its being prepared in a crystalline form. It appeared in these experiments as if the great length of time which elapsed before the crystals formed was owing to the salts not diffusing out rapidly enough; I therefore modified the form of the experiment by placing a vessel full of a dry salt inside a larger vessel containing a solution just sufficient in quantity to cover the inner vessel. A large precipitate formed on the undissolved salt, and in a few days little crystals were perceptible in the amorphous mass, which continued to grow as long as the materials lasted. In this way I hope to obtain good-sized crystals of heavyspar, calcspar, sulphate of lead (Schwerbleierz), pyromorphite ($3(PbO, PO_5)+PbCl$), apatite, &c. By diffusion of a solution of silicate of potash into one of aluminate of potash I hope to obtain felspar. The crystallization of very soluble compounds may be accomplished by a similar process. Thus, if a solution of sulphate of iron in a beaker-glass is covered with a thin stratum of water, and alcohol gently poured on the top of that, a good and rapid

crystallization is obtained. It is probable that in like manner crystals may be prepared from an acid, an alkaline, an alcoholic, or an ethereal solution; and that the separation of two bodies by alteration of the solvent, so often employed in organic chemistry, may thus be combined with a separation by means of crystallization.

The above-mentioned crystals were identified with the minerals without the aid of chemical analysis; but as in each experiment the number of possible results was limited, and as the crystals agreed in their general chemical deportment and in their physical properties, as well as in their mode of aggregation and geometrical forms with the minerals named, chemical analysis could hardly have increased the certainty of my conclusions.

[A. W. W.]

On Pseudo-apatite. By C. Rammelsberg.

[Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1853, p. 184: Poggend. Annal. lxxxv. p. 297.]

The substance distinguished by Breithaupt as Pseudo-apatite, from the Prince Augustus Mine, near Freiberg, is stated by the author to be without doubt an Apatite affected by decomposition, as its appearance clearly shows. The analysis gave—

Phosphoric acid	40·30	} 88·68 (40·30 + 48·38)	
Calcium	{ 48·38		} 53·78 (48·38 + 5·40)
	{ 5·40		
Magnesia	0·14		
Oxide of iron	1·78		
Carbonic acid (Loss)	4·00		
	100·00		

Fluor was not determined. Of chlorine there was a trace.

[T. R. J.]

On the Artificial Production of Apatite, Topaz, *and some other* Fluor-minerals. By A. Daubrée.

[Bull. Soc. Géol. France, Deux. Sér. tome viii. pp. 347–350.]

After referring to his former communication on certain experiments, that confirm the idea of some veins of tin and titanium ore having been derived from the decomposition of the chlorurets and fluorurets of these metals, M. Daubrée observes, that apatite, which is rare in veins of lead, copper, silver, and of most metals, but, on the contrary, very commonly found with tin-ore, may have probably owed its origin to the presence of the fluoruret and chloruret of phosphorus,

and that, by realizing in experiment the conditions suggested by geological observations, artificial apatite is easily obtained.

By passing a current of the vapour of perchloruret of phosphorus over caustic lime in a porcelain tube submitted to a dull red heat, after a reaction accompanied by a most vivid incandescence, there is formed chloruret of calcium and tribasic phosphate of lime. A portion of the chloruret of calcium remains free; another portion combines with the phosphate, and gives a chloro-phosphate, insoluble in water and in acetic acid, which has exactly the composition of natural apatite.

Under the microscope this chloro-phosphate appears as little hexagonal prisms: it has then not only the composition, but also the crystalline form of natural apatite: its density is 2·98, which is a little less than that of natural apatite, and this arises without doubt from the latter containing the fluoruret, instead of the chloruret of calcium, in a predominating quantity; the former of which has a density much greater than the latter.

If slacked lime or common carbonate of lime (chalk) be used instead of caustic lime, apatite is still obtained.

Magnesia treated in the same manner as the lime gives an anhydrous phosphate of magnesia, crystallized in a form derived from the right rhomboidal prism. But this phosphate does not retain the chloruret in the state of combination. This difference between the behaviour of magnesia and lime may explain how it is that magnesian apatite has not been found where the ordinary apatite so frequently occurs. Wagnerite, or magnesian apatite, indeed, has not been met with hitherto but at one locality in the Salzburg.

Alumina and the aluminate of sodium, treated like the lime, do not yield a compound answering to apatite.

Silex heated to redness in presence of a current of chloruret of phosphorus is very easily decomposed, and furnishes chloruret of silicium, which is disengaged with the chloruret of phosphorus. The facility of the decomposition of silex by chloruret of phosphorus furnishes apparently a convenient method for preparing the chloruret of silicium.

Having described the formation of a substance closely resembling topaz, obtained by submitting alumina at a white heat to the action of a current of fluoruret of silicium, and having noticed other bodies more or less resembling certain micas, chondrodite, and scheelite as the results of other combinations, M. Daubrée goes on to say—these two of the minerals characteristic of tin-ores, apatite and topaz, originate, like the crystallized oxide of tin itself, in the decomposition of chlorurets and fluorurets, and by a procedure differing from those hitherto employed in imitating these minerals. All these reactions confirm the theory of metalliferous veins which I proposed in 1841, viz. that they are due to the decomposition of volatile chlorurets and fluorurets arising from profound depths.

The author then alludes to the probably important part played by these gases in the metamorphosis of certain rocks, such as the topaz-rocks of Saxony, of Villa Rica in Brazil, where the topaz is pene-

trated by oligistic iron and rutile; and such also as the numerous metamorphic rocks characterized by the presence of apatite, like those of the Zillerthal, of St. Gothard, of Lake Ilmen, and of many places in the United States, and in Ceylon.

[T. R. J.]

The INSECT FAUNA *of the* TERTIARY FORMATION *of* ŒNINGEN *and* RADOBOJ *in Croatia*. By Dr. OSWALD HEER, Professor of Natural History, High School and Gymnasium, Zurich, and Director of the Botanic Garden. Three parts. 4to, Leipsic, 1847–1853. With 40 Lithographic Plates.

Die INSECTEN-FAUNA *der* TERTIARGEBILDE *von* ŒNINGEN *und von* RADOBOJ *in Croatien*. Von Dr. OSWALD HEER, Professor u. s. w.

THE first part (p. 230) of this elaborate and beautifully illustrated history of the Fossil Insects of Œningen and Radoboj appeared in 1847. It was devoted to the history of the *Coleoptera*, and formed the first part of the first division of the work—treating of the *special* history of this fauna—whilst the second division will embrace its *general* history. In this part 119 species are described and figured:—101 from Œningen, 14 from Radoboj, 3 from Parschlug, in Steyermark, and 2 from the Upper Rhine, Canton Zug. These 119 species belong to 79 genera (34 Families); the Œningen species belonging to 68 genera (33 Families).

In the second part (p. 264), 1849, figures and descriptions of 38 species of *Gymnognathi*, 3 species of *Neuroptera*, 80 of *Hymenoptera*, 9 of *Lepidoptera*, and 80 of *Diptera*, in all 210 species, are given.

The third part (p. 139), lately published, contains descriptions of 133 species of *Rhyncota*, belonging to 31 genera; these are illustrated in 15 plates.

It was the author's intention to have completed the *special* history in these three parts of his work, but 183 new species of Coleoptera that have come to hand will require a supplemental part. With this exception, however, these three parts embrace the special history of the remains of the seven orders of Insects as they occurred in this Tertiary Fauna of Central Europe; and the author may well say that he has here opened out a path through the still obscure Insect Kingdom of past ages; and with good reason does he hope, that hereby he may have cleared the way for further progress, and thrown some new light on the darkness of the Tertiary Periods*.

[T. R. J.]

[* For Prof. Heer's History of Insects and Notice of the Fossil Ants, see Quart. Journn. Geol. Soc. vol. vii. 2nd Part (Translations, &c.), pp. 61 & 68.]

GÉOLOGIE *appliquée aux* ARTS *et à l'*AGRICULTURE, *comprenant l'Ensemble des Révolutions du Globe.* Par MM. C. D'ORBIGNY et A. GENTE. pp. 534. 8vo, Paris, 1851. With Woodcuts, and an Engraved Table of the Geological Epochs illustrated by numerous figures of Organic Remains.

To meet the general demand of the numerous classes of readers and intelligent inquirers, who are thirsting for the means of self-instruction, especially the industrial and agricultural communities, the authors have prepared this work on geological science, rendering it as clear, and as free from technicalities, as circumstances would allow.

The general design of the work comprises three chief heads:—1. The study of geology and geognosy; embracing the subjects connected with the physical history of the earth, atmosphere, and waters, and with the structure and composition of the earth's crust: 2. Geology applied to the arts; treating of the rocks useful to man, whether of igneous or of sedimentary origin; and of the metalliferous and the non-metalliferous minerals, economically applied: 3. Geology in its relation to Agriculture; under which head the authors consider the vegetable soil; its formation; its principal elements, and their influence on vegetation; the classification of soils; the agency of light, air, heat, &c. on vegetation; the hygrometric and other physical properties of soils; and, lastly, the improvement of soils, or the application of inorganic manures.

The work is completed by the addition of a copious vocabulary of scientific terms used in the work, which also serves as an alphabetical index. Lastly, a general view of the stratigraphical relations of the deposits of the several geological periods is exhibited in an engraved tabular view of the *Terrains, Formations,* and *Etages,* chronologically arranged and severally accompanied by figures of their characteristic animals or plants. [T. R. J.]

On a new species of ANTHRACOTHERIUM. By HERMANN VON MEYER.

[Jahrbuch K. K. Geolog. Reichsanstalt, 1853, No. 1. p. 165.]

THE lower jaw of an *Anthracotherium* was lately found in a piece of brown-coal in the Barbara Mine, at Monte Promina, in Dalmatia. A careful drawing of the specimen was submitted to Von Meyer, who found that this fossil does not agree with any known species. It is nearest to *A. Sandbergeri,* from the Westerwald, but differs from it in the form of the last lower molars. Von Meyer names the new species *A. Dalmatinum.* [T. R. J.]

Note on the Fossil Plants from Shetland.

I find, upon reference to the Memoirs of the Wernerian Natural History Society, vol. i., that in the year 1808, the Rev. Dr. Fleming had already noticed the existence of plant-remains in the sandstones of the Shetland Isles.

I was unaware of this fact when I made the short communication respecting the supposed Devonian plants of Lerwick at p. 50 of this volume of the Journal.

The sandstone of Papa Stour*, says the Rev. Dr., "is exactly similar to the sandstone in the Islands of Foulah and Bressay. In the former of these islands [Foulah] the sandstone is accompanied with bituminous shale and clay-ironstone, and rests on gneiss as the fundamental rock. In Bressay the sandstone includes beds of clay-slate, and contains vegetable impressions, similar to those common in the sandstone of the coal-fields of the Lothians. Hence it seems reasonable to conclude that the different rocks in the island of Papa Stour, together with the sandstone of the Zetland Islands, belong to the Independent Coal Formation."—*Loc. cit.* pp. 174, 175.

This paragraph, although written forty-five years ago, is highly valuable, and shows that more extensive and precise surveys are required before we can draw the exact line of demarcation between the Old Red Sandstone and the Carboniferous deposits. My own opinion, however, remains for the present as before stated,—*i. e.* that the Shetland plants in question belong to the Upper Division of the Old Red Sandstone; between which formation and the Lower Coal Sandstones, that lie beneath or are associated with the Carboniferous Limestone, there exists a very intimate connection in several parts of Scotland.

[R. I. M.]

June 23, 1853.

* The two islands, Papa Stour and Foulah, lie on the western side of Shetland. Bressay, close to which Lerwick is situated, is on the eastern side.

ALPHABETICAL INDEX

TO THE

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

[The fossils referred to are described, and those of which the names are printed in italics are also figured.]

END OF VOL. IX.

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